PROCESS FOR THE PREPARATION OF TETRAZOLE DERIVATIVES FROM ORGANO BORON AND ORGANO ALUMINIUM AZIDES

The invention relates to a method for preparing substituted tetrazoles, compounds obtained according to this method, new reactants and new tetrazole derivatives.

Tetrazoles are structural elements, for example, of pharmaceuticals or agricultural compositions, foaming agents, automotive inflators, and the like. Especially mentioned are the class of so-called angiotensin II receptor antagonists also designated nowadays as angiotension receptor blockers (ARBs) that can be used e.g. for the treatment of hypertension and congestive heart failure. Most of said ARBs comprise as structural element a 5-tetrazole group.

It is known in the art that tetrazole derivatives can be prepared by reacting various nitriles with organic azides in relatively good yields. Representatives of corresponding azides are, for example, organo-tin azides which have some toxic profile. They have to be handled with special care in production processes, cause ecological problems and require a significant amount of additional process work to recycle them from the wastewater thereby additionally increasing the production costs. Tetrazole forming methods which use trialkylammonium azides or tetraalkylammonium azides may form volatile sublimates in the reaction reactors at higher temperatures which have the risk of explosion and are therefore not easy to handle in large scale production.

There is a strong need to develop process variants, new reagents and intermediates that avoid the above-mentioned disadvantages. Especially, a lot of effort has been made to substitute corresponding organo-tin azides with alternative agents which are viable alternatives in the production of tetrazoles with sufficiently high yields.

It has surprisingly been found that organo boron azides and organo aluminium azides can be used as alternatives to corresponding organo-tin compounds. Said boron and aluminium compounds are available in considerably large scales and are relatively inexpensive, especially corresponding aluminium compounds that are produced for the polymer industry (e.g. Ziegler-Natta catalysis). It has surprisingly turned out that high yields of tetrazoles can be achieved when using these organo azides to be used according to the present invention. Furthermore, as the corresponding boron and aluminium azides are not known to be toxic,

their use does not require special care when recycling the waste water and moreover the dialkylmetal azides can be produced in a large scale at low costs and mild conditions. Even though, corresponding dialkyl boron and dialkyl aluminium azides have these advantages, they have not been described in the literature to be used in [2+3]cycloadditions with nitriles to form tetrazoles. What is known from the literature is that e.g. di-organyl aluminium azides can be used to open epoxides and also to form acyl-azides from esters. However, the use of di-organyl boron or di-organyl aluminium azides, respectively, to form tetrazoles with nitriles is fully surprising.

The present invention relates to the use of organo boron and organo aluminium azides, especially as defined below, for the manufacture of tetrazole derivatives.

The present invention relates to a process for the manufacture of a tetrazole of formula

(I)
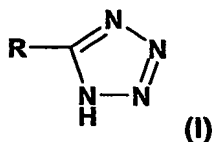
or a tautomer or a salt thereof, wherein R represents an organic residue;
comprising

(i)   reacting a compound of formula **R-CN (II a)** with an azide of formula **(R$_1$)(R$_2$)M-N$_3$ (II b)**, wherein R has the meaning as defined above; R$_1$ and R$_2$, independently of another, represent an organic residue such as an aliphatic residue, an alicyclic residue, a heteroalicyclic residue; an alicyclic-aliphatic residue; a heteroalicyclic-aliphatic residue; a carbocyclic or a heterocyclic aromatic residue; an araliphatic residue or an heteroaraliphatic residue, each residue, independently of another, being unsubstituted or substituted; and M is boron or aluminium; and

(ii)   isolating the resulting compound of formula (I).

A tautomer of a compound of formula (I) is a compound of formula

(I').
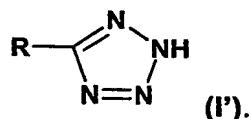
A salt of a compound of formulae (I) or (I'), if the compounds of formulae (I) or (I') have, for example, at least one basic centre, can be an acid addition salt. This is formed, for example, with a strong inorganic acid, with a strong organic carboxylic acid, or with an organic sulfonic acid. A corresponding acid addition salt can also be formed, if desired, with any additionally present basic centre. If the compounds of formulae (I) or (I') have at least one acid group (for example COOH or 5-tetrazolyl) a salt with a base can be formed. A suitable salt with bases is, for example, metal salts, or a salt with ammonia or an organic amine. A corresponding internal salt may furthermore be formed.

The general definitions used above and below of the corresponding residues, unless otherwise defined below, have the following meanings:

An organic residue is, for example; an aliphatic residue, an alicyclic residue, a heteroalicyclic residue; an alicyclic-aliphatic residue; a heteroalicyclic-aliphatic residue; a carbocyclic or a heterocyclic aromatic residue; an araliphatic residue or an heteroaraliphatic residue, each residue, independently of one another, being unsubstituted or substituted.

An aliphatic residue is, for example, alkyl, alkenyl or secondarily alkynyl, each of which can be interrupted by NH, substituted NH, O, or S; and each of which can be unsubstituted or substituted, for example, mono-, di- or tri-substituted.

Alkyl is, for example, C_1-C_{20}-alkyl, in particular C_1-C_{10}-alkyl. C_1-C_8-alkyl is preferred, for example methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl or tert-butyl.

Alkenyl is, for example, C_3-C_{20}-alkenyl, in particular C_3-C_{10}-alkenyl. Preferred is C_3-C_5-alkenyl; for example, 2-propenyl or 2- or 3-butenyl. Alkenyl is likewise C_2-C_{20}-alkenyl, in particular C_2-C_{10}-alkenyl. Preferred is C_2-C_5-alkenyl.

Alkinyl is, for example, C_3-C_{20}alkynyl, in particular C_3-C_{10}alkynyl. Preferred is C_3-C_5alkynyl such as propargyl. Alkinyl is likewise C_2-C_{20}alkynyl, in particular C_2-C_{10}alkynyl. Preferred is C_2-C_5alkynyl.

Alkyl, alkenyl or alkynyl that can be interrupted by NH, substituted NH, O or S is in particular C_1-C_{20}-alkoxy- C_1-C_{20}-alkyl, -C_3-C_{20}-alkenyl or - C_3-C_{20}-alkynyl, or C_3-C_{20}-alkenyloxy- C_1-C_{20}-

alkyl, - C_3-C_{20}-alkenyl or - C_3-C_{20}-alkynyl, for example, C_1-C_{10}-alkoxy-C_1-C_{10}-alkyl, -C_3-C_{10}-alkenyl or - C_3-C_{10}-alkynyl, or C_3-C_{10}-alkenyloxy-C_1-C_{10}-alkyl, -C_3-C_{10}-alkenyl or -C_3-C_{10}-alkynyl. Preferred is C_1-C_7-alkoxy-C_1-C_7-alkyl, -C_3-C_7-alkenyl or - C_3-C_7-alkynyl, or C_3-C_7-alkenyloxy-C_1-C_7-alkyl, -C_3-C_7-alkenyl or - C_3-C_7-alkynyl.

Substituted NH is, for example, NH which is substituted by C_1-C_8-alkyl such as methl, ethyl or propyl, phenyl-C_1-C_8-alkyl such as benzyl or 2-phenethyl, or by acyl, such as C_2-C_8-alkyl-alkanoyl, phenyl-C_2-C_5-alkanoyl, benzoyl, C_1-C_8-alkanesulfonyl or benzenesulfonyl.

An alicyclic residue is, for example, mono-, bi- or polycyclic. Preferred is cycloalkyl and secondarily cycloalkenyl, each of which can also be substituted.

Cycloalkyl in particular C_3-C_8cycloalkyl. Preferred is cyclopentyl and cyclohexyl.

Cycloalkenyl is in particular C_3-C_7cycloalkenyl and is preferably cyclopent-2- and -3-enyl, or cyclohex-2- and -3-en-yl.

A heteroalicyclic residue is, for example, an alicyclic residue, wherein at least one carbon atom is replaced by a heteroatom, e.g. NH, substituted NH, O, or S, each of which can also be substituted.

An alicyclic aliphatic residue is, for example, alkyl, alkenyl or alkynyl that is substituted by cycloalkyl or by cycloalkenyl. Preferred is C_1-C_8-alkyl, C_2-C_8-alkenyl or C_2-C_8-alkynyl each of which is substituted by C_3-C_8-cycloalkyl or by C_3-C_8-cycloalkenyl, especially cyclopropylmethyl, cyclopentylmethyl, cylohexylmethyl, or cyclohexenyl-methyl.

A heterocyclic aliphatic residue is, for example, C_1-C_8-alkyl, C_2-C_8-alkenyl or C_2-C_8-alkynyl each of which substituted by C_3-C_8cycloalkyl or by C_3-C_8-cycloalkenyl wherein one carbon atom of C_3-C_8cycloalkyl or by C_3-C_8-cycloalkenyl, respectively, is replaced by NH, substituted NH, O, or S, especially piperidino-methyl or -ethyl.

A carbocyclic aromatic residue is, for example, a mono- or polycyclic (such as bicyclic) or benzoanellated carbocyclic residue, such as phenyl, naphthyl, but also biphenyl, each of which can also be substituted.

A heterocyclic aromatic residue is, for example, 5- or 6-membered and monocyclic radical which has up to four identical or different hetero atoms, such as nitrogen, oxygen or sulfur atoms, preferably one, two, three or four nitrogen atoms, an oxygen atom or a sulfur atom, each of which can also be substituted. Appropriate 5-membered heteroaryl radicals are, for example, monoaza-, diaza-, triaza-, tetraaza-, monooxa- or monothia-cyclic aryl radicals, such as pyrrolyl, pyrazolyl, imidazolyl, triazolyl, tetrazolyl, furyl and thienyl, while suitable appropriate 6-membered radicals are in particular pyridyl.

An araliphatic residue is, for example, C_1-C_8-alkyl, C_2-C_8-alkenyl or C_2-C_8-alkynyl each of which is substituted by phenyl or by naphthyl, especially benzyl, 2-phenethyl or 2-phenyl-ethenyl.

A heteroaraliphatic residue, is for example, C_1-C_8-alkyl, C_2-C_8-alkenyl or C_2-C_8-alkynyl each of which is substituted by pyrazolyl, imidazolyl, triazolyl, tetrazolyl, furyl, thienyl or pyridyl, especially pyridylmethyl.

Alkyl, alkenyl, or alkinyl can also be substituted, for example, by a substituent selected from the group consisting e.g. of an alicyclic residue, a heteroalicyclic residue; a carbocyclic and a heterocyclic aromatic residue; each residue, independently of another, being unsubstituted or substituted by one or more, e.g. two or three, substituents, for example, selected from the group consisting of halogen, amino, substituted amino, mercapto, substituted mercapto, hydroxyl, etherified hydroxyl, carboxy, and amidated carboxy.

Alicyclic or heteroalicyclic residues can also be substituted, for example, by one or more, e.g. two or three, substituents selected from the group consisting e.g. of an aliphatic residue, alicyclic residue, a heteroalicyclic residue; a carbocyclic and a heterocyclic aromatic residue; each residue, independently of another, being unsubstituted or substituted by one or more, e.g. two or three, substituents, for example, selected from the group consisting of halogen; amino, substituted amino, mercapto, substituted mercapto, hydroxyl, etherified hydroxyl, carboxy, and amidated carboxy.

An alicyclic-aliphatic residue, a heteroalicyclic-aliphatic residue, an araliphatic residue or a heteroaraliphatic residue, each residue (e.g. in both the alicyclic and the aliphatic moiety),

independently of another, being unsubstituted or substituted by one or more, e.g. two or three, substituents in both structural elements, for example, selected from the group consisting of an aliphatic residue, an alicyclic residue, a heteroalicyclic residue; an alicyclic-aliphatic residue; a heteroalicyclic-aliphatic residue; a carbocyclic aromatic residue, a heterocyclic aromatic residue; an araliphatic residue; an heteroaraliphatic residue, halogen; amino, substituted amino, mercapto, substituted mercapto, hydroxyl, etherified hydroxyl, carboxy, and amidated carboxy.

A carbocyclic or a heterocyclic aromatic residue can also be substituted, for example, by one or more, e.g. two or three, substituents selected from the group consisting e.g. of an aliphatic residue, alicyclic residue, a heteroalicyclic residue; a carbocyclic and a heterocyclic aromatic residue; each residue, independently of another, being unsubstituted or substituted by one or more, e.g. two or three, substituents, for example, selected from the group consisting of halogen; amino, substituted amino, mercapto, substituted mercapto, hydroxyl, etherified hydroxyl, carboxy, and amidated carboxy.

Substituents of an aliphatic residue, an alicyclic residue, a heteroalicyclic residue; an alicyclic-aliphatic residue; a heteroalicyclic-aliphatic residue; a carbocyclic or a heterocyclic aromatic residue; an araliphatic residue or an heteroaraliphatic residue, can likewise be acetalized formyl.

Halogen is in particular halogen of atomic number not more than 53, such as fluorine, chlorine, bromine and iodine.

Substituted mercapto is, for example, substituted by an aliphatic residue, an alicyclic residue, a heteroalicyclic residue; an alicyclic-aliphatic residue; a heteroalicyclic-aliphatic residue; a carbocyclic or a heterocyclic aromatic residue; an araliphatic residue or an heteroaraliphatic residue, each residue, independently of another, being unsubstituted or substituted by one or more, e.g. two or three, substituents, for example, selected from the group consisting of halogen; amino, substituted amino, mercapto, substituted mercapto, hydroxyl, etherified hydroxyl, carboxy, and amidated carboxy.

Etherified hydroxy is, for example, hydroxy etherified by an aliphatic, an alicyclic, heteroalicyclic, an araliphatic, a heteroaryl-aliphatic, a carbocyclic aromatic or heteroaromatic alcohol, each of which can also be substituted.

Esterified carboxy is, for example, carboxy which is esterified by an alcohol which is derived from an aliphatic or araliphatic hydrocarbon radical, such as alkyl, phenyl-alkyl, alkenyl and secondarily alkynyl, and which may be interrupted by -O-, such as alkoxy-alkyl, -alkenyl and - alkynyl. Examples which may be mentioned are C_1-C_7alkoxy-, phenyl-C_1-C_7alkoxy-, C_2-C_7alkenyloxy- and C_1-C_7alkoxy-C_1-C_7alkoxy-carbonyl.

Amidated carboxyl is, for example, carbamoyl in which the amino group is unsubstituted or monosubstituted or, independently of one another, disubstituted by an aliphatic or araliphatic hydrocarbon radical or disubstituted by a divalent aliphatic hydrocarbon radical which may be interrupted by O or may be condensed at two adjacent carbon atoms with a benzene ring, in particular alkylene or lower alkyleneoxy-alkylene. Examples of appropriately substituted amino groups which may be mentioned are C_1-C_7alkyl-, C_2-C_7alkenyl-, C_2-C_7alkynyl-, phenyl-C_1-C_7alkyl-, phenyl-C_2-C_7alkenyl-, phenyl-C_2-C_7alkynyl-, di-C_1-C_7alkyl-, N- C_1-C_7alkyl-N-phenyl-C_1-C_7alkyl- and diphenyl-C_1-C_7alkylamino and also quinol-1-yl, isoquinol-2-yl, C_1-C_7alkylene- and C_1-C_7alkyleneoxy-C_1-C_7alkylene-amino.

Alkylene is, for example, C_1-C_{10}alkylene, in particular, C_1-C_7alkylene, for example methylene, ethylene, or 1,5-pentylene. Corresponding alkylene may also be branched.

Substituted amino has the meanings indicated in connection with substituted carbamoyl and is furthermore acylamino, such as C_2-C_8- alkanoyl-, phenyl-C_2-C_5-alkanoyl-, benzoyl-, C_1-C_8-alkanesulfonyl- or benzenesulfonylamino.

Acetalised formyl is, for example, di-alkoxymethyl or oxy-alkyleneoxymethylene. Most preferred is branched oxy-alkylene-oxy-methylene wherein the alkylene group is branched such as oxy-2,3-butylene-oxy-methylene or oxy-2,3-di-methyl-2,3-butylene-oxy-methylene.

Alkanoyl is, for example, C_2-C_{10}alkanoyl and is in particular C_2-C_7alkanoyl, such as acetyl, propionyl, butyryl, isobutyryl or pivaloyl. C_2-C_5alkanoyl is preferred.

Haloalkylsulfamoyl is in particular halo-C_1-C_{10}alkanesulfamoyl and is in particular C_2-C_7 alkanesulfamoyl, for example, trifluoromethane-, difluoromethane-, 1,1,2-trifluoroethane- or heptafluoropropanesulfamoyl. Halo-C_1-C_4alkanesulfamoyl is preferred.

Pyrrolyl is, for example, 2- or 3-pyrrolyl. Pyrazolyl is 3- or 4-pyrazolyl. Imidazolyl is 2- or 4-imidazolyl. Triazolyl is, for example, 1,3,5-1H-triazol-2-yl or 1,3,4-triazol-2-yl. Tetrazolyl is, for example, 1,2,3,4-tetrazol-5-yl, furyl is 2- or 3-furyl and thienyl is 2- or 3-thienyl, while suitable pyridyl is 2-, 3- or 4-pyridyl or corresponding N-oxido-pyridyl.

Alkoxy is, for example, C_1-C_{20}alkoxy, in particular C_1-C_{10}alkoxy. Preferred is C_1-C_7alkoxy, most preferred C_1-C_4alkoxy such as methoxy, ethoxy, n-propyloxy or tert-butyloxy.

Substituents of residues as mentioned above and below should preferably not comprise those substituents that interfere with the reactants.

Preferred R is selected from the group consisting of phenyl or of pyridyl each of which is unsubstituted or substituted by a substituent selected from the group consisting of halogen, C_1-C_7alkyl, C_1-C_7alkoxy, hydroxyl, hydroxyl-C_1-C_7alkyl, halo-C_1-C_7alkyl such as CF_3, formyl, di-C_1-C_7alkoxy-methyl, and C_2-C_7alkylene-methyl; of C_3-C_7cycloalkyl; of C_3-C_7cycloalkenyl; of biphenylyl that is unsubstituted or substituted by a substituent selected from the group consisting of halogen, C_1-C_7alkyl, C_1-C_7alkoxy, hydroxyl, hydroxyl-C_1-C_7alkyl, halo-C_1-C_7alkyl such as CF_3, formyl, di-C_1-C_7alkoxy-methyl, and C_2-C_7alkylene-methyl, for example 4'-C_1-C_4alkyl-biphenyl-2-yl, 4'-hydroxy-C_1-C_4alkyl-biphenyl-2-yl, 4'-halo-C_1-C_4alkyl-biphenyl-2-yl, 4'-formyl-biphenyl-2yl, 4-di- di-C_1-C_4alkoxy-methyl, or C_2-C_5alkylene-methyl; of C_1-C_7alkyl that is unsubstituted or substituted by a substituent selected from the group consisting of halogen, of phenyl; of phenylsulphonyl, of

phenylsuphinyl, and of phenylmercapto, phenyl being in each case unsubstituted or substituted by a substituent selected from the group consisting of halogen, C_1-C_7alkyl, C_1-C_7alkoxy, hydroxyl, hydroxyl-C_1-C_7alkyl, and halo-C_1-C_7alkyl such as CF_3; of carboxy, and of N-phenyl-N-C_1-C_7alkyl-amino phenyl being in each case unsubstituted or substituted by a substituent selected from the group consisting of halogen, C_1-C_7alkyl, C_1-C_7alkoxy, hydroxyl, hydroxyl-C_1-C_7alkyl, and halo-C_1-C_7alkyl such as CF_3; and of C_2-C_7alkenyl that is unsubstituted or substituted by a substituent selected from the group consisting of halogen, of phenyl; of carboxy, and of N-phenyl-N-C_1-C_7alkyl-amino phenyl being in each case unsubstituted or substituted by a substituent selected from the group consisting of halogen, C_1-C_7alkyl, C_1-C_7alkoxy, hydroxyl, hydroxyl-C_1-C_7alkyl, and halo-C_1-C_7alkyl such as CF_3.

Specifically preferred R is selected from the group consisting of halophenyl such as 2-, 4-chlorophenyl, 2-fluorophenyl; of hydroxyphenyl such as 2-hydroxyphenyl; of CF_3-phenyl such as 2-CF_3-phenyl; of halo-pyridyl such as 2-chloro-5-pyridyl; of hydroxy-pyridyl such as 2-hydroxy-5-pyridyl; of biphenyl that is substituted by C_1-C_4-alkyl, halo-C_1-C_4-alkyl, hydroxyl-C_1-C_4-alkyl, or formyl; of phenyl-C_2-C_4-alkenyl; of 1-carboxy-2-phenyl-C_2-C_4-alkenyl, such as 4'-methyl-biphenyl-2-yl, 4'-bromomethyl-biphenyl-2-yl, 4'-formyl-biphenyl-2-yl, or 4-hydroxymethyl-biphenyl-2-yl; of carboxy-C_1-C_4-alkyl, for example, carboxy-methyl; of phenylsulphonyl-C_1-C-alkyl such as phenylsulphonyl-methyl; of phenylmercapto-C_1-C_4-alkyl such as phenylmercaptomethyl; of C_3-C_6-cycloalkyl such as cyclopropyl or cyclobutyl; of C_3-C_6-cycloalkenyl such as 1-cyclohexenyl; and of N-phenyl-N'-C_1-C_4-alkyl-amino-C_1-C_4-alkyl such as 2-(N-phenyl-N'-methyl-amino)-methyl.

The reactions described above and below in the variants are carried out, for example, in the absence or, customarily, in the presence of a suitable solvent or diluent or a mixture thereof, the reaction, as required, being carried out with cooling, at room temperature or with warming, for example, in a temperature range from about -80°C up to the boiling point of the reaction medium, preferably from about -10° to about +200°C, and, if necessary, in a closed vessel, under pressure, in an inert gas atmosphere and/or under anhydrous conditions.

Preferably, a compound of formula (II a) is used, wherein substituents of variable R do not interfere during the reaction with a compound of formula (II b).

A compound of formula (II a) is preferably a corresponding compound, wherein R is as defined above.

A preferred azide of formula $(R_1)(R_2)M$-N_3 (II b) is a corresponding compound, wherein M is aluminium or boron, R_1 and R_2, independently of one another, is C_1-C_8-alkyl such as methyl, ethyl, propyl, diisobutyl, tert-butyl or n-octyl; C_3-C_7alkenyl such as allyl or crotyl, C_3-C_7-cycloalkyl such as cyclohexyl; phenyl-C_1-C_4-alkyl such as benzyl or 2-phenethyl; phenyl-C_3-C_5alkenyl such as cinnamyl, or C_3-C_8-cycloalkyl-C_1-C_8-alkyl such as cyclopropylmethyl or cyclohexylmethyl. Likewise, R_1 and R_2, independently of one another, is phenyl-C_2-C_5alkenyl.

Especially preferred azides are those as mentioned in the Examples.

The molar ratio of an azide of formula (II b) and a nitrile of formula (II a) is in a range from 5 to 1, preferably, from 3 to 1, most preferably, from 1,8 to 1 or from 1,2 to 1.

An inert solvent, diluent or mixture thereof should be selected which means that it cannot react with the starting material or intermediates. A suitable solvent is, for example, selected from the group consisting of aliphatic, cycloaliphatic and aromatic hydrocarbon, such as an C_5-C_{10}-alkane e.g. heptane, a cycloalkane such as cyclohexane; and alkylated C_3-C_7cycloalkane such as methyl-cyclohexane or 1,3-dimethyl-cyclohexane, an alkylated benzene such as ethylbenzene, toluene, xylene, cumene, or mesitylene; a halogenated aromatic solvent such as chlorobenzene, o-, m- or p-chlorotoluene, dichlorobenzene, and trifluoromethylbenzene which may be further substituted e.g. by C_1-C_7alkyl or C_1-C_7alkoxy; and a halogenated hydrocarbon, for example, a halogenated aromatic compound, such as chlorobenzene. A further solvent may be an ether, such as tetrahydrofurane. Furthermore, a suitable solvent, diluent or mixture thereof should have a boiling point that is high enough to be used under the reaction conditions.

Preferred solvents or diluents are aliphatic hydrocarbons, for example, C_6-C_9alkanes such as heptane or n-octane; aromatic hydrocarbons, for example, phenyl substituted by C_1-C_4alkyl such as toluene or xylene, or mixtures thereof.

The reaction temperature is preferred in the temperature range of from room temperature to the boiling point of the solvent, diluent or mixture thereof, for example, a reaction temperature range is from about 20°C to about 170°C, preferably, from about 60°C to about 130°C or to about 140°C, depending on the reactivity and combination of the reactants. A person skilled in the art is fully enabled to select corresponding suitable solvent and diluent systems and reaction conditions adapted to the choice of the solvent system and reactants.

The reaction is most preferably carried out under anhydrous conditions.

In a preferred embodiment of the present invention, the invention is carried out in a temperature range of from 80°C to 120°C , preferably between 90°C and 110°C.

The isolation step is carried out according to conventional isolation methods, such as by crystallizing the resulting compound of formula (I), (IV), (IV c), (V), (VI), (VII), or (VII'), respectively, or a tautomer or salt thereof, from the reaction mixture or by chromatography of the reaction mixture, such as by crystallizing the resulting compound from the reaction mixture – if desired or necessary after work-up, especially by extraction - or by chromatography of the reaction mixture. Reference in this context is also made to the working examples.

Compounds of formula (II a) are either known or can be prepared using methods known in the art.

Preferred are compounds of formula (II a), wherein R represents a carbocyclic or heterocyclic residues.

The present invention likewise relates to a compound of formula (II b). Preferred compounds of formula (II b) are those, wherein R_1 and R_2, independently of one another, are C_1-C_{10}alkyl, C_3-C_8alkenyl, C_3-C_8-cycloalkyl, alkylated C_3-C_8-cycloalkyl or ar-C_1-C_5alkyl,

especially methyl, ethyl, isopropyl, butyl, isobutyl, octyl, allyl, cyclopropyl, cyclopentyl, cyclohexyl, methyl-cyclohexyl, or benzyl.

Azides of formula (II b) can be prepared, for example, by reacting a compound of formula $(R_1)(R_2)M-X$ (II c), wherein M is aluminium or boron, R_1 and R_2 have the meanings as defined above and X is a leaving group e.g. halogen, such as fluoride, chloride, bromide or iodide; or a sulphonate, such as an alkane sulfonate e.g. methanesulphonate; a halogenated alkane sulfonate e.g. trifluoromethansulfonate, an aromatic sulphonate e.g. tosylate; with an azide, preferably an alkaline metal azide, such as a lithium, sodium or potassium azide.

The formation of an azide of formula (II b) is carried out, in particular, in the presence of an inert solvent or diluent or a mixture thereof, in a temperature range of 0°C to 120°C. The reaction is most preferably carried out under anhydrous conditions.

Preferred azides comprise compounds of formula (II b), wherein R_1 and R_2, independently of one another, represent C_1-C_8-alkyl such as ethyl, iso-propyl, n-propyl, n-butyl, sec-butyl, tert-butyl or n-octyl, C_3-C_8-cycloalkyl, C_3-C_8-cycloalkyl-C_1-C_8-alkyl or aryl-C_1-C_8-alkyl such as benzyl or 2 phenethyl; and M is boron or aluminium. Corresponding representatives are dimethyl aluminium azide, diethyl aluminium azide, diisopropyl aluminium azide, dipropyl aluminium azide, diisobutyl aluminium azide, dibutyl aluminium azide, dicyclohexyl aluminium azide, diethyl boron azide, diisopropyl boron azide, dipropyl boron azide, diisobutyl boron azide, dibutyl boron azide or dicyclohexyl boron azide, furthermore diaryl boron azide such as diphenyl boron azide.

It might be that, dependent on the kind of substituents, reactive substituents could also react with the azide. For example, an aromatic hydroxy group or a benzylic hydroxyl group may react with an azide of formula (II b), however, the resulting hydroxy function masked by a metal or by an organo metal group can be split with e.g. an acid resulting in a compound of formula (I); accordingly, in this situation, a higher amount of a compound of formula (II a) needs to be used. An ester group might form an acyl-azide with a compound of formula (II b), while an epoxy ring structure might be opened with an compound of formula (II b). However, the person skilled in the art would be able to either directly anticipate that starting compounds with specific reactive substituents could not be used, as these substituents might react with the azide instead of the cyano function, or the person skilled in the art

would, when corresponding side reactions are realized, protect corresponding reactive groups and lateron split-off the corresponding protecting groups by using conventional methods known per se.

The process of the present invention likewise comprises protecting reactive substituents of compounds of formulae (II a) and (II b) and, after formation of the tetrazole ring, splitting-off the corresponding protective group(s), especially by using conventional methods known per se e.g. by the person skilled in the pertinent art who is familiar with protecting and de-protecting functional groups.

In a preferred embodiment of the present invention, before the reaction of a compound of formula (II a) with a compound of formula (II b), a compound of formula (II a) wherein R comprises a reactive group that can be protected against the reagent of formula (II b) can be protected. Then a resulting protected compound is reacted as described herein with a compound of formula (II b) and from a resulting compound the protecting groups is split off resulting in a compound of formula (I) or a tautomere thereof. This principle can likewise be applied to the manufacture of a compound of formulae (IV), (V), (VI), respectively.

In a preferred embodiment of this variant, OH groups, such as aromatic e.g. phenolic or benzylic OH groups, can be either masked or protected, respectively. A corresponding OH group can be masked, for example, by treatment with a compound of formula (II d) $M'(R_3)_n$ wherein M' represents a suitable element of groups 1a, 2a, 3a, and 4 a of the Periodic Table of Elements, especially an element selected from the group consisting of Li, Na, K, Mg, Ca, B, Al, and Si; R_3, independently of one another, is hydrogen, a leaving group such as halogen e.g. chlorine or bromine, NH_2, alkyl such as C_1-C_8-alkyl, cycloalkyl such as C_3-C_7-cycloalkyl e.g. cyclopropyl or cyclohexyl, carbocyclic aryl such as phenyl or substituted phenyl, carbocyclic aryl-alkyl such as phenyl-C_1-C_4-alkyl e.g. benzyl or 1- or 2-phenethyl, C_1-C_8-alkoxy such as methoxy, ethoxy, isopropyloxy, tert-butyloxy, n-octyloxy, and the index "n" corresponds to the valence of the element M'. R_3 can only represent one leaving group such as halogen.

A preferred compound of formula (II d) comprises corresponding alkaline metal hydride or amide such as NaH, KH, $NaNH_2$, KNH_2; CaH_2 and MgH_2, a corresponding alkaline metal

organyl, for example, M'-C_1-C_8-alkyl such as isobutyl-Li, butyl-Li, isobutyl-Li, tert-butyl-Li, n-hexyl-Li, n-hexyl-Li.

A preferred compound of formula (II d) comprises a corresponding alkaline metal alcoholate such as sodium or potassium C_1-C_5-alkanolate.

A preferred compound of formula (II d) comprises a corresponding C_1-C_8-alkyl, C_3-C_7-cycloalkyl, phenyl or substituted phenyl organyl formed with B or Al such as trimethyl-Al, triethyl-Al, or a corresponding C_1-C_8-alkoxy organyl formed with B or Al such as trimethoxy-B, triethoxy-B, triisoproyloxy-B, tri-butyloxy-B and tri-n-butyloxy-B.
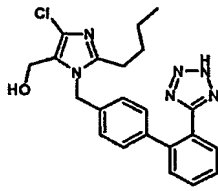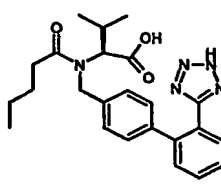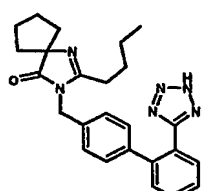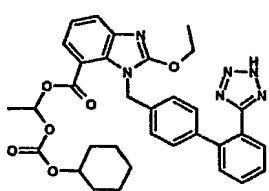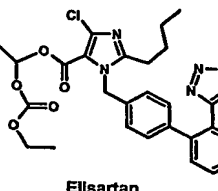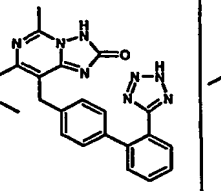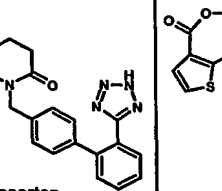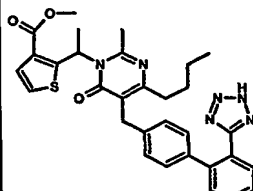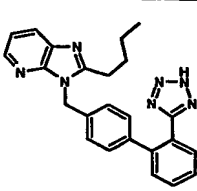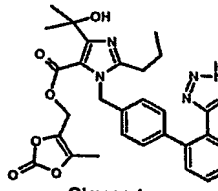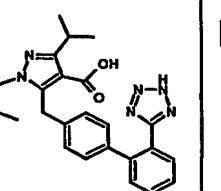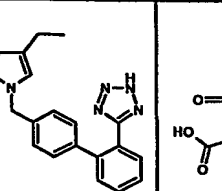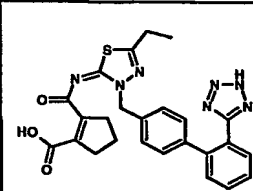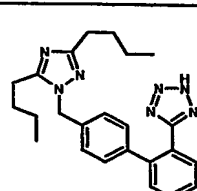
A preferred compound of formula (II d) comprises a corresponding halide of C_1-C_8-alkyl, phenyl-C_1-C_4-alkyl, C_3-C_7-cycloalkyl, phenyl or substituted phenyl organyl formed with Si such as trimethyl-Si-chloride, triethyl-Si-chloride, tribenzyl-Si-chloride, tert-buty-diphenyl-B-chloride, and triphenyl-Si-chloride.

Most preferred is LiH, but also trimethyl-Al and triethyl-Al.

A reactive group of a compound of formula (II a), for example, a corresponding OH group, can also be protected, for example, by a suitable OH protecting group.

Most angiotensin II receptor antagonists have two essential structural elements, the so-called "core element" and the "pharmacophore element".

Examples for corresponding angiotensin II receptor antagonists can be taken from following table:

| Losartan (MSD) | Valsartan (Novartis) | Irbesartan (Sanofi, BMS) | Candesartan-Cilexetil (Takeda) |
| Elisartan (Hafslund, Nycomed) | Ripisartan (BMS) | Tasosartan (Wyeth-Ayerst) | Milfasartan (Lusofarmaco, Menarini) | FK-739 (Fujisawa) |
| Olmesartan (Sankyo, Recordati) | UR-7247 (Uriach) | YM-358 (Yamanouchi) | KRH-94 (Kissel) | SC-52458 (Searle) |

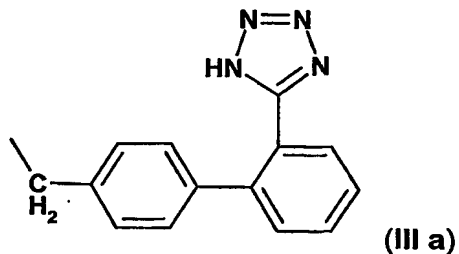The core part of angiotensin II receptor antagonists comprises e.g. core elements derived from above table, for example, following structural elements:
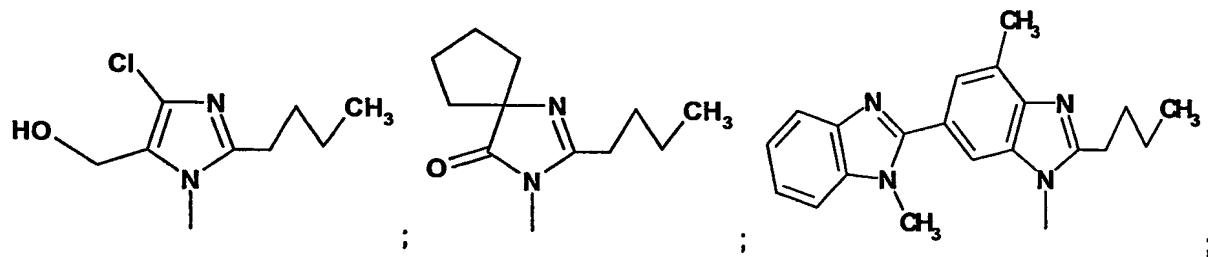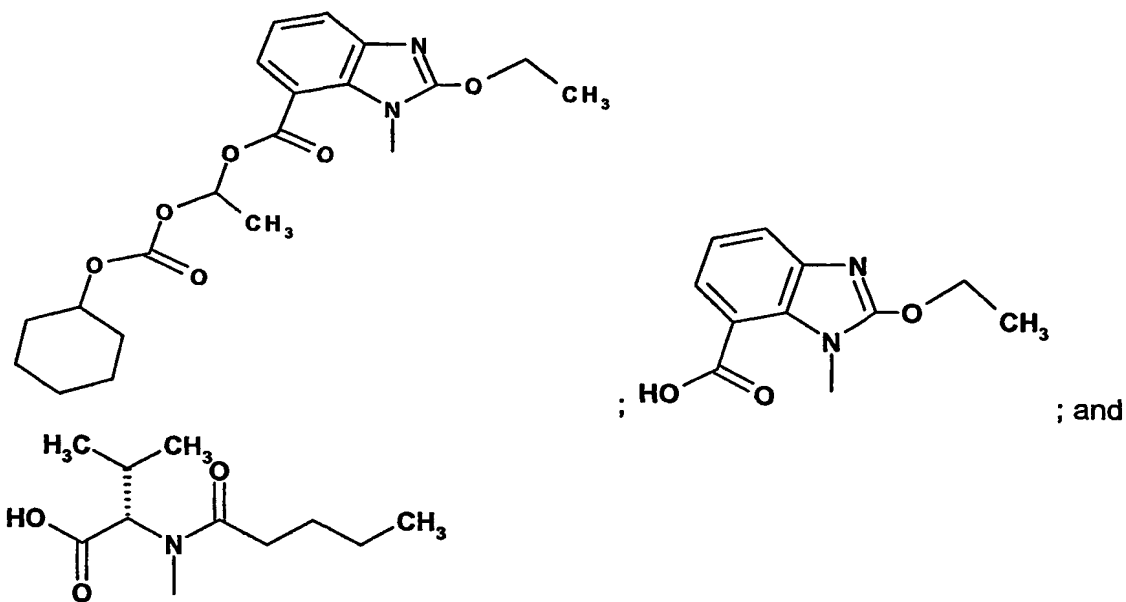
A further preferred core part of an angiotensin II receptor antagonist has following structure:
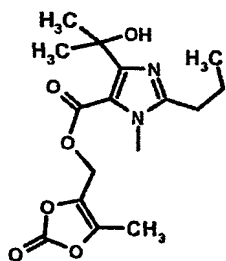
The pharmacophore element of corresponding angiotensin II receptor antagonists is represented by formula

(III a)

or is a tautomeric form thereof.

A tautomeric form of the side chain of formula (III a) is represented by formula (III b)
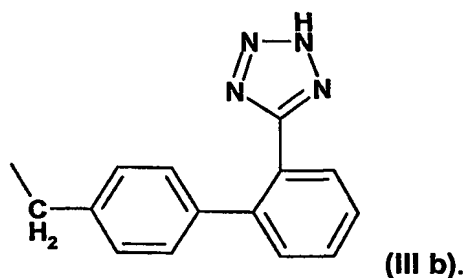
(III b).

The present invention likewise relates to a process for the manufacture of said angiotensin II receptor antagonists having as structural feature side the chain of formula (III a) is represented by formula


(III a)
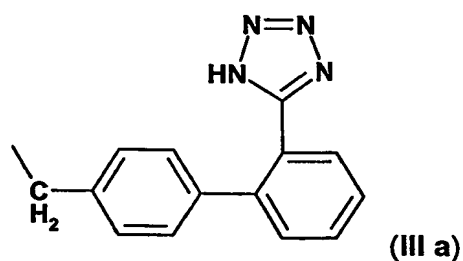
or a tautomeric form thereof, especially of . angiotensin II receptor antagonists as shown in above table.

The present invention likewise relates to a process for the manufacture of said angiotensin II receptor antagonists having as structural feature a tetrazol ring, e.g. of formula (IV),

(IV)
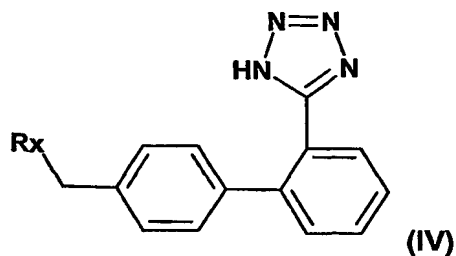
or a tautomeric form thereof, wherein Rx represents a structural element corresponding to the relevant "core elements" derived from the above table, especially a structural element selected from the group consisting of
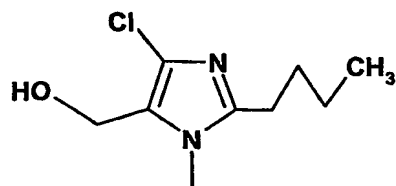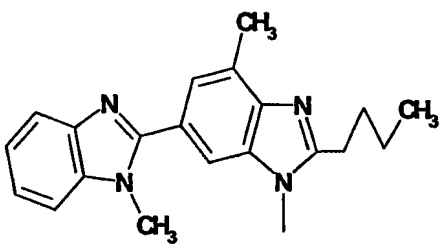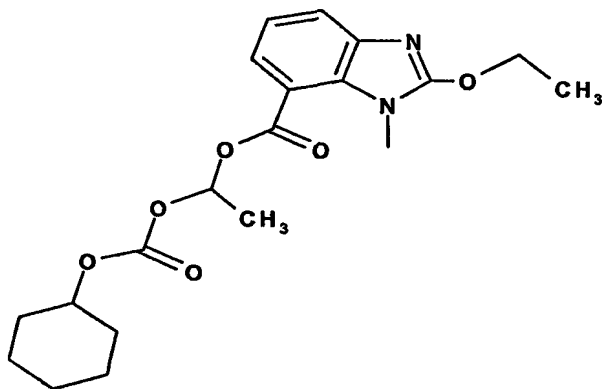
(derived from losartan - cf. EP 253310);
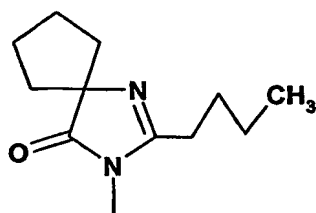
(derived from irbesartan - cf. EP 454511);

(derived from UR-7247);

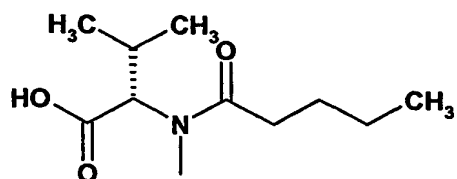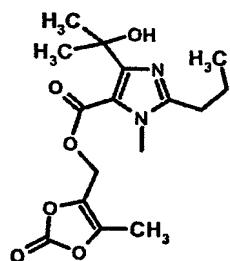(derived from candesartan-cilexetril- EP 459136);
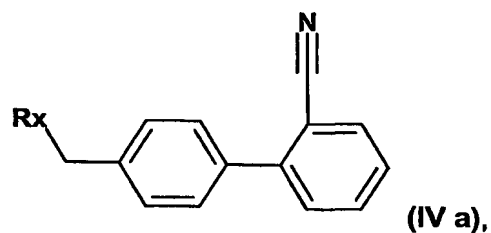
(derived from candesartan); and

(derived from valsartan - cf. EP 443983);

(derived from olmesartan – cf. EP 503785)

or, in each case, a salt thereof.

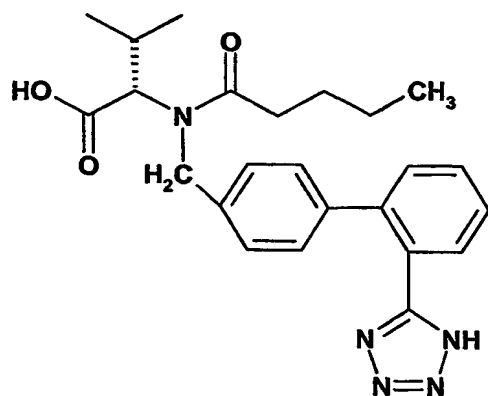This process is characterized by reacting a compound of formula (IV a)

(IV a),

wherein Rx has the meanings as given above,

with a compound of formula (R₁)(R₂)M-N₃ (II b'), wherein R_1 and R_2, independently of one another, represent an organic residue; and isolating the resulting compound of formula (IV).
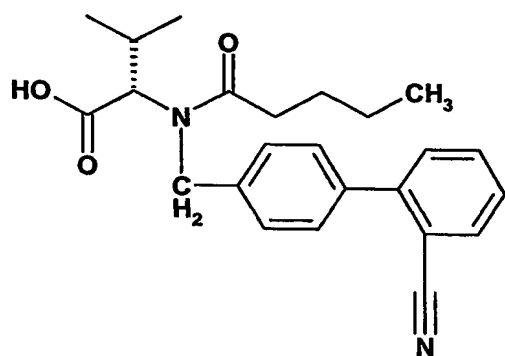

A preferred angiotensin II receptor antagonist is the compound of formula

(IV b) or a tautomer thereof.

A preferred variant of the process according to the present invention for the manufacture of a compound of formula (IV b) is characterized by reacting a compound of formula (IV c)


(IV c)

or an ester thereof with an azide of formula $(R_1)(R_2)M\text{-}N_3$ **(IIb)**, wherein R_1 and R_2, independently of each other, have the meanings as defined above, and isolating the compound of formula (IV b).

An ester of a compound of formula (IV c) is, for example, an ester derived from an aliphatic, araliphatic, cycloaliphatic, cycloaliphatic-aliphatic or aromatic alcohol. Preferred is a C_1-C_7-alkyl ester or a aryl-C_1-C_2-alkyl ester, most preferred a benzylester thereof.

A preferred embodiment of the present invention is a process for the manufacture of a compound of formula

(V)
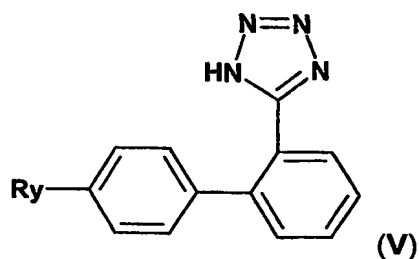
a tautomeric form thereof wherein Ry represents C_1-C_8-alkyl such as methyl; C_1-C_8-alkyl substituted by X' and X' being halogen, sulphonyloxy, hydroxyl, protected hydroxyl, such as bromomethyl, or an acetal of formyl; and X_1 being in a benzylic position, comprising reacting a compound of formula (IV a)
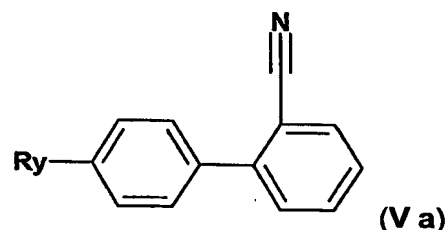
(V a)

with a compound of formula $(R_1)(R_2)$-M-N_3 **(II b)**, wherein R_1 and R_2, independently of one another, represent an organic residue; and isolating the resulting compound of formula (V).

An acetal of a formyl group is, for example, the corresponding di-C_1-C_8alkoxymethyl such as dimethoxy- or diethoxy-methyl, or methylene-oxy-C_2-C_8-alkylene-oxy such as methyleneoxy-ethyleneoxy.

The present invention likewise relates to the above reaction. Furthermore, the present invention relates to the compounds of formula (V) or a tautomer or a salt thereof in a form being completely free of tin. The present invention also relates to compounds of formula (V) whenever obtained according to above reaction.

A variant of the process for the manufacture of the compound of formula (V) is a process for the manufacture of a compound of formula (VI)

(VI)

or a tautomer or salt thereof, comprising

(a) treating a compound of formula (VI a)

(VI a),
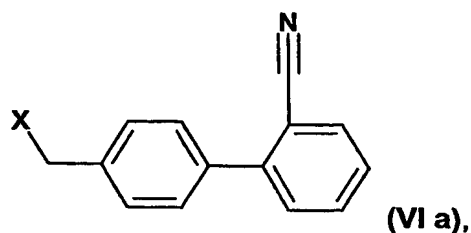
wherein X represents a leaving group, first with a nucleophilic agent and then with a "solvolytic" base resulting in a compound of formula (VI b)
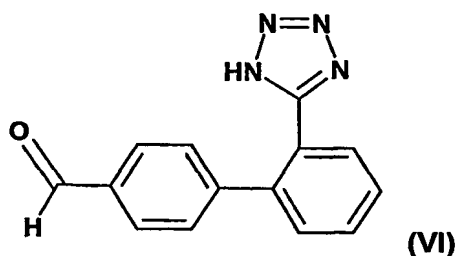

(VI b);
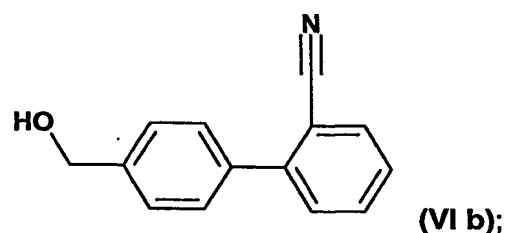
(b) reacting a compound of formula (V b) with an azide of formula $(R_1)(R_2)M-N_3$ **(II b)**, wherein the variables R_1 and R_2, independently of one another, have the meanings as defined above; resulting in a compound of formula (VI c)

(VI c) or a tautomer or salt thereof
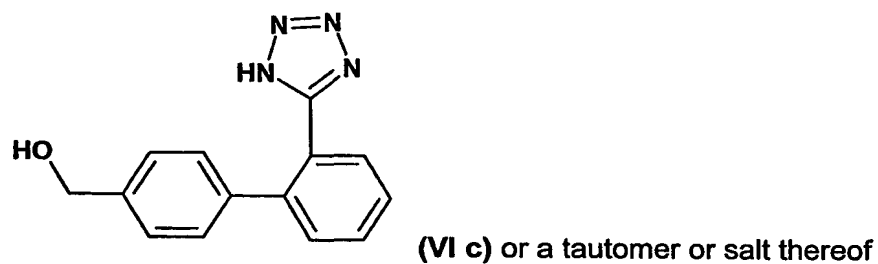
(c) oxidizing a compound of formula (VI c) or a tautomer or salt thereof resulting in a compound of formula (VI)

(VI)
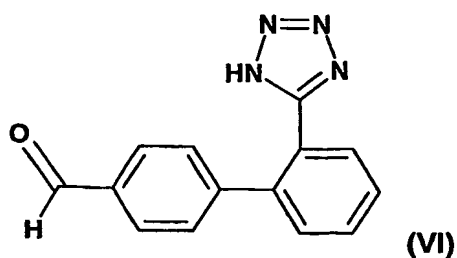
or a tautomer or salt thereof; and

(d) isolating the compound of formula (VI) or a tautomer or salt thereof.

The present invention relates to each of reaction steps (a) to (c) and to the product obtained according to the complete reaction sequence, but also according to each of reaction steps (a) to (c).

The reactions described above and below in the variants are carried out in a manner known per se, for example in the absence or, customarily, in the presence of a suitable solvent or diluent or a mixture thereof, the reaction, as required, being carried out with cooling, at room temperature or with warming, for example in a temperature range from about -80°C up to the boiling point of the reaction medium, preferably from about -10° to about +200°C, and, if necessary, in a closed vessel, under pressure, in an inert gas atmosphere and/or under anhydrous conditions.

Step (a) is carried out, for example, in the presence of a base, e.g. first a nucleophilic agent followed by treatment with a saponifying base. .

A suitable nucleophilic agent is, for example, an alkaline metal salt of a C_2-C_{10}-alkanecarboxylic acid, especially of a C_2-C_5-alkanecarboxylic acid, an araliphatic carboxylcic acid or an aromatic carboxylic acid, or aliphatic ammonium acetates, especially tetra-C_1-C_7-alkyl-ammonium acetates. Examples comprise e.g. lithium acetate, sodium acetate, potassium acetate, and tetraethylammonium acetate.

Suitable saponifying bases are, for example, alkali metal hydroxides, hydrides, amides, alkanolates, carbonates, or lower alkylsilylamides, naphthaleneamines, lower alkylamines, basic heterocycles, ammonium hydroxides, and carbocyclic amines. Examples which may be mentioned are sodium hydroxide, sodium hydride, sodium amide, sodium methoxide, sodium ethoxide, potassium tert-butoxide, potassium carbonate, benzyltrimethylammonium hydroxide, 1,5-diazabicyclo[4.3.0]non-5-ene (DBN) and 1,8-diaza-bicyclo[5.4.0]undec-7-ene (DBU), the last two bases preferably in the presence of water.

Suitable saponifying bases are preferably used in the presence of water. At least stochiometric amounts of water is used, especially a molar access of water is preferred.

Likewise, in a specially preferred embodiment Step (a) is carried out in the presence of a phase transfer catalyst, for example, those known in the art. Suitable phase transfer catalysts comprise tri-C_1-C_8-alkyl-ar-C_1-C_5alkyl-ammonium halides such as corresponding chlorides or bromides, tetra-C_1-C_8-alkyl-ammonium halides such as corresponding chlorides or bromides, di-C_1-C_8-alkyl-diar-C_1-C_5alkyl-ammonium halides such as corresponding chlorides or bromides. Examples are tetrabutyl ammonium bromide or triethylbenzylammonium chloride.

More than one mol equivalent of a base is normally used, preferably from 1.1 to 1.5 equivalents.

An inert solvent or a mixture of solvents is used. Suitable solvents comprise e.g. hydrocarbons such as heptane, octane, toluene or xylene, a halogenated hydrocarbons such as methylenechloride, 1,2-dichloroethane, chlorobenzene, fluorobenzene or trifluorobenzene.

The reaction temperature is, for example, from 0°C to the boiling point of the solvent, preferably from 0°C to 130°C, more preferably from 40°C to 80°C.

The present invention relates to the reaction Step (a). This reaction step comprises two separate steps and it is suprising that the yield is nearly quantitative (> 99% by weight theory). The present invention also relates to compounds of formula (VI b) whenever obtained according to process Step (a).

Step (b): The molar ratio of an azide of formula (II b) and a nitrile of formula (VI b) is in a range from 5 to 1, preferably, from 3 to 1, most preferably, from 1,8 to 1 or from 1,2 to 1.

An inert solvent, diluent or mixture thereof should be selected which means that it cannot react with the starting material or intermediates. A suitable solvent is, for example, selected from the group consisting of aliphatic, cycloaliphatic and aromatic hydrocarbon, such as an C_5-C_{10}-alkane e.g. heptane, a cycloalkane such as cyclohexane; an alkylated C_3-C_7cycloalkane such as methyl-cyclohexane or 1,3-dimethyl-cyclohexane, an alkylated benzene such as ethylbenzene, toluene, xylene, cumene, or mesitylene; a halogenated

aromatic solvent such as chlorobenzene, chlorotoluene, dichlorobenzene, and trifluoromethylbenzene; a halogenated hydrocarbon, for example, a halogenated aromatic compound, such as chlorobenzene. Furthermore, a suitable solvent, diluent or mixture thereof should have a boiling point that is high enough to be used under the reaction conditions.

Preferred solvents or diluents are aliphatic hydrocarbons, for example, C_6-C_9alkanes such as heptane; aromatic hydrocarbons, for example, phenyl substituted by C_1-C_4alkyl such as toluene or xylene, or mixtures thereof.

The reaction temperature is preferred in the temperature range of from room temperature to the boiling point of the solvent, diluent or mixture thereof, for example, a reaction temperature range is from about 20°C to about 170°C, preferably, from about 60°C to about 130°C, depending on the reactivity and combination of the reactants. A person skilled in the art is fully enabled to select corresponding suitable solvent and diluent systems and reaction conditions adapted to the choice of the solvent system and reactants.

The reaction is most preferably carried out under anhydrous conditions.

In a preferred embodiment of the present invention, the invention is carried out in a temperature range of from 80 to 120°C , preferably between 90 and 110°C.

The present invention likewise relates to reaction Step (b). Furthermore, the present invention relates to the compounds of formula (VI c) or a tautomer or a salt thereof in a form being completely free of tin. The present invention also relates to compounds of formula (VI c) whenever obtained according to process Step (b).

Step (c): The oxidation is carried out in the presence of a suitable oxidizing agent. A suitable oxidizing agent is for example, an alkali metal hypochlorite such as lithium or sodium or potassium hypochlorite, calcium hypochlorite, "a Tempo" or an analogue (cf. Fluka) thereof or an oxidizing agent selected from the group consisting of HNO_2, HNO_3 or corresponding anhydrides thereof, and peroxodisulfates.

When using e.g. an alkali metal hypochlorite as oxidizing agent, the oxidation is carried out, for example, in an inert solvent, e.g. a solvent that is inert against oxidation, such as a lower alkanecarboxylic acid, for example acetic acid, a heterocyclic aromatic, for example pyridine, a halogenated hydrocarbon, alkane nitrile, for example, acetonitrile, or water or a mixture thereof, if necessary with cooling or warming, for example from about 0° to about 50°C, for example, at room temperature. In a preferred variant, the reaction is carried out in an aqueous medium and in the presence of a base. A suitable base is, among others, an alkaline carbonate, such as potassium carbonate.

When using oxidizing agents such as HNO_2, HNO_3 or corresponding anhydrides thereof, or peroxodisulfates, especially nitric acid, in a preferred variant an alkylated aromatic hydrocarbon such as toluene or xylene may be used as solvent. In a preferred variant of the oxidization with as HNO_2, HNO_3 or corresponding anhydrides thereof, or peroxodisulfates, the reaction is preferably carried out in a temperature range from about 0°C to room temperature or to 60°C. Surprisingly, no oxidation of the solvent is observed; i.e. the methyl groups in toluene or xylene are resistant to oxidation. Accordingly, the use of oxidizing agents such as HNO_2, HNO_3 or corresponding anhydrides thereof, or peroxodisulfates is likewise a subject matter of the present invention as is reaction Step c), especially when using as oxidizing agents such as HNO_2, HNO_3 or corresponding anhydrides thereof, or peroxodisulfates in the an alkylated aromatic hydrocarbon solvent, especially in toluene and xylene. In another preferred variant, HNO_3 is used in water free form or in an aqueous solution from about 40% to about 95%, preferably from 40 to 65 %.

The use of oxidizing agents such as HNO_2, HNO_3 or corresponding anhydrides thereof, or peroxodisulfates, especially nitric acid, provides surprising results. For example, the corresponding oxidization to an aldehyde is effected without further oxidizing the aldehyde function to the carboxy group. Accordingly, the use of said oxidizing agents is likewise a subject matter of the present invention.

The present invention also relates to compounds of formula (VI) whenever obtained according to process Step (c).

Step (d): The isolation step of a compound of formula (VI) is carried out according to conventional isolation methods, such as by crystallizing the resulting compound of formula
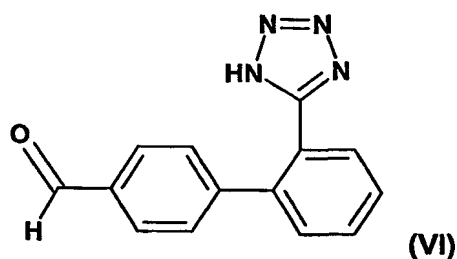
(VI) from the reaction mixture – if desired or necessary after work-up, especially by extraction - or by chromatography of the reaction mixture.

The present invention furthermore relates to a process for the manufacture of the compound of formula (IV b)
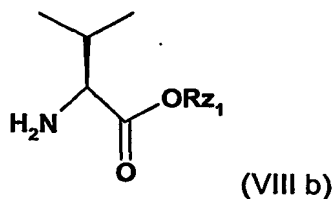

(IV b)
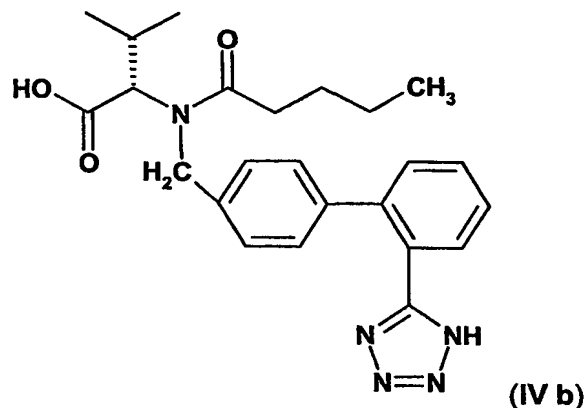
or a tautomer thereof or a salt thereof, comprising

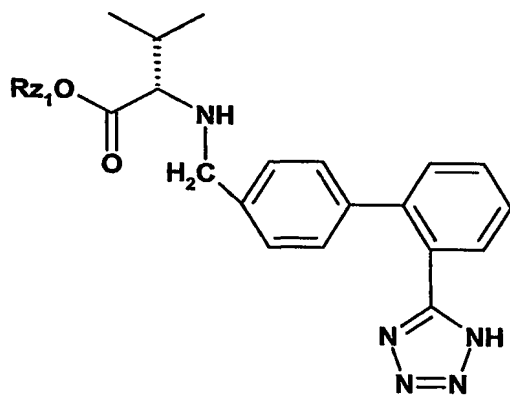(a')   reacting a compound of formula (VI)

(VI)

or a tautomer or salt thereof or a salt thereof, wherein the tetrazole ring is unprotected or protected by a tetrazole protecting group, with a compound of formula (VIII b)


(VIII b)

or a salt thereof, wherein R_{z1} represents hydrogen or a carboxy protecting group, under the conditions of a reductive amination; and

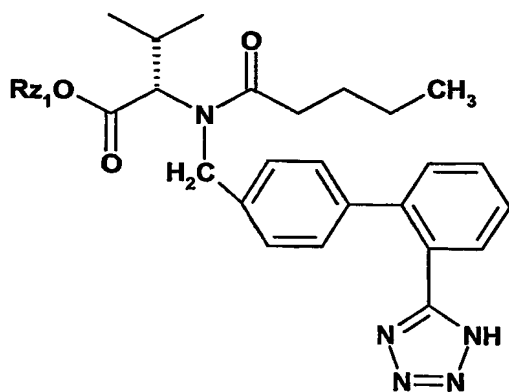(b') acylating a resulting compound of formula (VIII c)

(VIII c), or a tautomer thereof or a salt thereof, with a compound of formula (VIII d), wherein R_{z1} represents hydrogen or a carboxy protecting group and wherein the tetrazole ring is unprotected or protected by a tetrazole protecting group, with a compound of formula (VIII d)
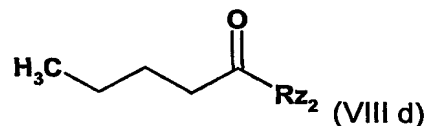
wherein R_{z2} is an activating group; and,and,

(c') if R_{z1} is different form hydrogen, and/or the tetrazole ring is protected by a protecting group, removing the protecting group(s) in a resulting compound of formula (VIII e)

(VIII e) or a tautomer or a salt thereof; and

(d') isolating a resulting compound of formula (IV b) or a salt thereof; and, if desired, converting a resulting free acid of formula (IV b) into a salt thereof or converting a resulting salt of a compound of formula (IV b) into the free acid of formula (IV b) or converting a resulting salt of a compound of formula (IV b) into a different salt.

The present invention likewise relates to a process for the manufacture of a compound of formula (IV b) or a tautomer or a salt thereof comprising the reaction sequence comprising the full sequence comprising steps (a) to (c) for the manufacture of a compound of formula (VI) and then subsequent steps (a') to (d') for the manufacture of a compound of formula (IV b).

The reactions described above and below in the variants are carried out, for example, in the absence or, customarily, in the presence of a suitable solvent or diluent or a mixture thereof, the reaction, as required, being carried out with cooling, at room temperature or with warming, for example in a temperature range from about -80°C up to the boiling point of the reaction medium, preferably from about -10°C to about +200°C, and, if necessary, in a closed vessel, under pressure, in an inert gas atmosphere and/or under anhydrous conditions.

Compounds of formulae (VIII a), (VIII b), (VIII c) and (VIII e), wherein either or both of R_1 and R_2 are hydrogen can form salts with bases, as both the unprotected tetrazole ring and the unprotected carboxy group have acidic properties, while compounds of formulae (VIII b) and (VIII c) can also form salts with acids.

A corresponding tetrazole protection group is selected from those known in the art. Especially, the tetrazole protecting group is selected from the group consisting of tert-C_4-C_7- alkyl such as tert-butyl; C_1-C_2-alkyl that is mono-, di or trisubstituted by phenyl, such as benzyl or benzhydryl or trityl, wherein the phenyl ring is un-substituted or substituted by one or more, e.g. two or three, residues e.g. those selected from the group consisting of tert-C_1- C_7-alkyl, hydroxy, C_1-C_7alkoxy, C_2-C_8-alkanoyl-oxy, halogen, nitro, cyano, and trifluoromethyl (CF_3); picolinyl; piperonyl; cumyl; allyl; cinnamoyl; fluorenyl; silyl such as tri-C_1-C_4-alkyl-silyl, for example, trimethyl-silyl, triethylsilyl or tert-butyl-dimethyl-silyl, or di-C_1-C_4-alkyl-phenyl- silyl, for example, dimethyl-phenyl-silyl; C_1-C_7-alkyl-sulphonyl; arylsulphonyl such as phenylsulphonyl wherein the phenyl ring is un-substituted or substituted by one or more, e.g. two or three, residues e.g. those selected from the group consisting of C_1-C_7-alkyl, hydroxy, C_1-C_7-alkoxy, C_2-C_8-alkanoyl-oxy, halogen, nitro, cyano, and CF_3; C_2-C_8-alkanoyl such as acetyl or valeroyl; and esterified carboxy such as C_1-C_7-alkoxy-carbony, for example, methoxy-, ethoxy- or tert-butyloxy-carbonyl; and allyloxycarbonyl. Examples of preferred

protective groups which may be mentioned are tert-butyl, benzyl, p-methoxybenzyl, 2-phenyl-2-propyl, diphenylmethyl, di(p-methoxyphenyl)methyl, trityl, (p-methoxyphenyl)diphenylmethyl, diphenyl(4-pyridyl)methyl, benzyloxymethyl, methoxymethyl, ethoxymethyl, methylthiomethyl, 2-tetrahydropyranyl, allyl, trimethylsilyl and triethylsilyl.

A corresponding carboxy protecting group (R_{z1}) is selected from those known in the art. Especially, R_{z1} is selected from the group consisting of C_1-C_7-alkyl such as methyl, ethyl or a tert-C_4-C_7-alkyl, especially tert-butyl; C_1-C_2-alkyl that is mono-, di or trisubstituted by phenyl, such as benzyl or benzhydryl, wherein the phenyl ring is un-substituted or substituted by one or more, e.g. two or three, residues e.g. those selected from the group consisting of C_1-C_7-alkyl, hydroxy, C_1-C_7-alkoxy, C_2-C_8-alkanoyl-oxy, halogen, nitro, cyano, and CF_3; picolinyl; piperonyl; allyl; cinnamyl; tetrahydrofuranyl; tetrahydropyranyl; methoxyethoxy-methyl, and benzyloxymethyl. A preferred example of protective groups which may be mentioned is benzyl.

The activating group R_{z2} is, for example, an activating group that is being used in the field of peptides, such as halogen such as chlorine, fluorine or bromine; C_1-C_7-alkylthio such as methyl-thio, ethyl-thio or tert-butyl-thio; pyridyl-thio such as 2-pyridyl-thio; imidazolyl such as 1-imidazolyl; benzthiazolyl-oxy such as benzthiazolyl-2-oxy-; benzotriazol-oxy such as benzotriazolyl-1-oxy-; C_2-C_8-alkanoyloxy, such as butyroyloxy or pivaloyloxy; or 2,5-dioxo-pyrrolidinyl-1-oxy. Examples of an activating group which may be mentioned are ???

Step (a'):
In reaction Step (a'), the reductive amination is carried out in the presence of a reducing agent. A suitable reducing agent is a borohydride, which may also be in a complexed form, or hydrogen or a hydrogen donor both in the presence of a hydrogenation catalyst. Furthermore, a reducing agent is a suitable selenide or a silane.

A suitable borohydride or a complexed borohydride is, for example, an alkali metal borohydride such as sodium borohydride or lithium borohydride; an earth alkali metal borohydride such as calcium borohydride; an alkali metal cyanoborohydride, such as sodium cyanoborohydride or lithium cyanoborohydride, an alkali metal tri-(C_1-C_7-alkoxy)-borohydride such as sodium trimethoxy-ethoxy-borohydride; a tetra-C_1-C_7-alkylammonium-

(cyano)borohydride such as tetrabutylammonium-borohydride or tetrabutylammonium-cyanoborohydride.

A suitable catalyst for the reductive amination with hydrogen or a hydrogen donor is, for example, nickel, such as Raney nickel, and noble metals or their derivatives, for example oxides, such as palladium, platinium or platinum oxide, which may be applied, if desired, to support materials, for example to carbon or calcium carbonate, for example, platinium on carbon. The hydrogenation with hydrogen or a hydrogen donor may preferably be carried out at pressures between 1 and about 100 atmosphere and at room temperature between about -80° to about 200°C, in particular between room temperature and about 100°C.

A preferred hydrogen donor is, for example, a system comprising 2-propanol and, if desired, a base, or, most preferably, formic acid or a salt thereof, e.g. an alkali metal, or tri-C_1-C_7-alkyl-ammonium salt thereof, for example, the sodium or the potassium salt thereof, if desired, in the presence of a tertiary amine, such as triethylamine. Further hydrogen donors comprise other alcohols such as ethanol, 2-methoxyethanol, benzyl alcohol, benzhydrol, pentan-2-ol, 1,2-ethandiol, 2,3-butandiol or cyclohexandiol, hydrazine, cyclohexene, cyclohexadiene, indane, tetralin, indoline, tetrahydroquinoline, hydroquinone, hypophosphinic acid or a suitable salt thereof such as the sodium salt thereof, sodium tetrahydroborate, sugars, ascorbic acid, limonene, or silanes. The hydrogen donor may also be used as solvent, especially 2-propanol or formic acid.

A suitable selenide is, for example, selenophenol which is unsubstituted or substituted. Suitable substituents comprise, for example, one, two or three substituents selected from e.g. halo, trifluoromethyl, trifluoromethoxy, C_1-C_7-alkyl, C_1-C_7-alkoxy, nitro, cyano, hydroxyl, C_2-C_{12}-alkanoyl, C_1-C_{12}-alkanoyloxy, and carboxy. Those silanes are preferred that are completely soluble in the reaction medium and that may moreover produce organic soluble by-products. Especially preferred are tri-C_1-C_7-alkyl-silanes, especially triethylsilane and tri-isopropyl-silane. Preferred are commercially available selenides.

A suitable silane is, for example, silane which is trisubstituted by a substituent selected from the group consisting of C_1-C_{12}-alkyl, especially C_1-C_7-alkyl, and C_2-C_{30}-acyl, especially C_1-C_8-acyl. Preferred are commercially available silanes.

The reductive amination is preferably carried out under acidic, neutral or preferably under basic conditions. A suitable base comprises, for example, an alkali metal hydroxide or carbonate, such as sodium hydroxide, potassium hydroxide or potassium carbonate. Furthermore, an amine base can be used, for example, tri-C_1-C_7-alkylamine, such as triethylamine, tri-n-propylamine, tri-butylamine or ethyl-diisopropylamine, a piperidine, such as N-methylpiperidine, or a morpholine, such as N-methyl-morpholine. Preferred bases include lithium hydroxide, sodium hydroxide, sodium hydrogencarbonate, sodium carbonate, potassium hydrogencarbonate and potassium carbonate. Especially preferred is sodium hydroxide, sodium carbonate or tri-n-propylamine.

The reductive amination is carried out in a suitable inert solvent or a mixture of solvents including water. Inert solvents conventionally do not react with the corresponding starting materials of formulae (VIII a) and (VIII b). If an alkali metal borohydride such as sodium borohydride or lithium borohydride; an earth alkali metal borohydride such as calcium borohydride; an alkali metal cyanoborohydride, such as sodium cyanoborohydride or lithium cyanoborohydride, is used as reducing agent, for example, a polar solvent, for example, an alcohol such as methanol, ethanol, isopropanol or 2-methoxyethanol, or glyme, is preferred. If an alkali metal tri-(C_1-C_7-alkoxy)-borohydride such as sodium trimethoxy-ethoxy-borohydride; a tetra-C_1-C_7-alkylammonium-(cyano)borohydride such as tetrabutylammonium-borohydride or tetrabutylammonium-cyanoborohydride, is used as reducing agent, for example, hydrocarbons, such as toluene, esters such as ethylacetate or isopropylacetate, ethers such as tetrahydrofuran or tert-butylmethylether are preferred. If hydrogen or a hydrogen donor is used as reducing system, each in the presence of a hydrogenation catalyst, a polar solvent is preferred. The reductive amination can also be carried out e.g. in a mixture of an organic solvent with water, both mono- and biphasic. In a biphasic system a phase transfer catalyst such as tetrabutylammoniumhalide, e.g. bromide, or benzyltrimethylammonium halide, e.g. chloride, may be added.

If R_{z1} represent a protecting group and the tetrazole ring is protected and if the compound of formula (VIII b) is a free base, the presence of a base is not required. If, however, R_{z1} is hydrogen and the tetrazole ring is protected by a protecting group, not more than a molar equivalent of a base may be added. In order to avoid racemisation, the reaction is preferably carried out by using less than an equimolar amount of a base. If R_{z1} is hydrogen and the tetrazole ring is not protected, no racemisation is observed even if the reaction is

carried out with equal or more than one equivalent of base under mild conditions, preferably at temperatures between -10°C and 20°C.

The reaction of a compound of formula (VIII a) with a compound of formula (VIII b) results in an intermediately formed imine (Schiff base) of formula (VIII c")

(VIIIc")
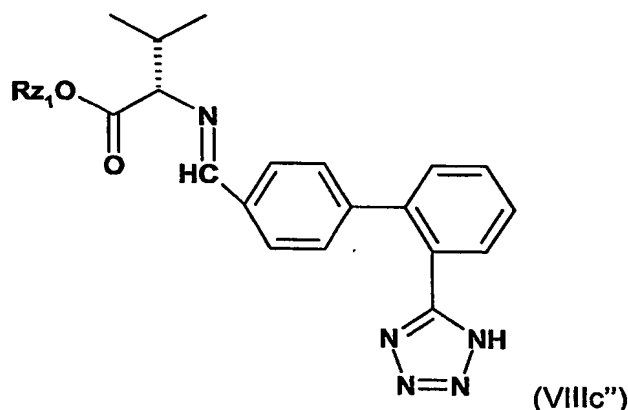
or a tautomer or a salt thereof, whwerein R_{z1} has the meaning as given above and wherein the tetrazole ring is unprotected or protected by a tetrazole protecting group that can, under certain reaction conditions, be isolated or that can be subjected to the reduction without isolation.

The reductive amination is a two-step reaction, the formation of an imine by removing water, followed by the reduction step. The removal is an equilibrium reaction, which can be directed to the formation of an imine by continously eliminating the water, for example, by azeotropic removal. Furthermore, a water scavenger may be used to remove or inactivate free water which may be effected by a physical process such as absorption or adsorption or by a chemical reaction. A suitable water scavenger includes without limitation anhydrides of organic acid, aluminosilicates such as molecular sieves, other zeolites, finely divided silica gel, finely divided aluminia, anhydrides of inorganic acids such as phosphoric anhydride (P_2O_5), inorganic sulfates such as calcium sulfate, sodium sulfate, and magnesium sulfate, and other inorganic salts such as calcium chloride.

If Step (a') is carried out via first manufacturing and isolating a compound of formula (VIII c"), a compound of formula (VIII a) is reacted with a compound of formula (VIII b), maybe in the presence of a base, if R_{z1} is hydrogen and the tetrazole ring is not protected.. Compounds of

formula (VIII c") can then be converted into corresponding compounds of formula (VIII c') by reducing the compounds of formula (VIII c") with a corresponding reducing agent as mentioned above.

The intermediate imine of formula (VIII c") can, for example, be isolated by removal of the solvent, e.g. by distillation, especially by azeotropic removal of water.

In a preferred variant, the reductive amination is carried out without isolating a compound of formula (VIII c').

The reductive amination is most preferably carried out without removal of free water, especially, if R_{z1} is hydrogen and the tetrazole ring is not protected and with a base such as sodium hydroxide, a solvent such as methanol and a reducing reagent such as sodium borohydride.

In view of the imine structural element, compounds of formula (VIII c") comprise both the corresponding E and the corresponding Z isomer thereof. Preferred is the E isomer.

The present invention likewise relates to compounds of formula (II c') wherein R_1 is hydrogen or a tetrazole protecting group and wherein R_2 is hydrogen or a carboxy protecting group. Corresponding compounds can be used as intermediates for the manufacture of the compound of formula (I). Preferred are compounds of formula (II c'), wherein at least one of R_1 and R_2 represents hydrogen or both of R_1 and R_2 represent hydrogen.

The compounds of formulae (VIII a) and (VIII b) are partially known and can be prepared according to methods known per se.

Step (a') is preferably carried out under mild conditions, especially in a temperature range of about -10°C to about room temperature, preferable in a range of about -5°C and +5°C.

Step (b'):

In reaction Step (b'), the acylation is carried out, for example, in absence or in presence of a suitable base.

Suitable bases are, for example, alkali metal hydroxides or carbonates, morpholine or piperidine amines, unsubstituted or substituted pyridines, anilines, naphthalene amines, tri-C_1-C_7-alkylamines, basic heterocycles or tetra-C_1-C_7-alkyl-ammonium hydroxides. Examples, which may be mentioned, include sodium hydroxide, potassium carbonate, triethylamine, tri-propyl-amine, tri-butyl-amine or ethyldiisopropylamine, N-methyl-morpholine or N-methyl-piperidine, dimethyl-aniline or dimethylamino-naphthalene, a lutidine, a collidine, or benzyltrimethylammonium hydroxide. A preferred base is a tri-C_1-C_4-alkylamine such as ethyl-diisopropyl-amine or is pyridine.

The acylation is carried out in a suitable inert solvent or in a mixture of solvents. The person skilled in the art is fully enabled to select a suitable solvent or solvent system. For example, an aromatic hydrocarbon such as toluene, an ester such as ethylacetate or a mixture of ethylacetate and water, a halogenated hydrocarbon such as methylene chloride, a nitrile such as acetonitrile of proprionitrile, an ether such as tetrahydrofurane or dioxane, 1,2-dimethoxy-ethane, amide such as dimethylformamide, or a hydrocarbon, such as toluene, is used as solvent.

During the acylation of a compound of formula (VIII c), if R_2 is hydrogen, the carboxyl-group might also be acylated forming a mixed anhydride. This intermediate is strongly prone to racemisation, mainly under basic conditions. Racemisation however can be avoided by first adding the compound of formula (VIII d), especially the halide, to the compound of formula (VIIIc) in a suitable inert solvent (e.g. dimethoxyethane, tetrahydrofuran or acetonitril), then slowly adding a sub-stoichiometric amount of the base, especially pyridine, in relation to the compound of formula (VIII d). Small amounts of water in the reaction mixture, preferably two equivalents, may additionally suppress racemisation.

The reaction can also be carried out by simultaneous or alternative addition of a compound of formula (VIII d) and a base such as pyridine keeping the reaction mixture acidic at all times.

If R_{z1} represents a protecting group and the tetrazole ring is unprotected or protected by a protecting group, for example, two equivalents of both a compound of formula (VIII d), e.g. the corresponding halide thereof, and a base, e.g. ethyl-diisopropyl-amine or tri-n-propylamine are added to a corresponding compound of formula (VIII c) dissolved in a suitable solvent, e.g. toluene. No racemisation is observed.

If the tetrazole ring is unprotected and R_{z1} is a protecting group, the tetrazole ring might also be acylated. When, however, the reaction mixture is quenched, for example with water or an alcohol such as methanol, the corresponding compound can be obtained wherein the tetrazole ring is unprotected.

Compounds of formula (VIII d) are known or can be manufactured according to methods known per se.

Step (c'):

The removal of the protecting groups, both the tetrazole and carboxy protecting group, can be carried out according to methods known per se in the art.

For example, a benzylester can be converted into the corresponding acid especially by hydrogenation in the presence of a suitable hydrogenation catalyst. A suitable catalyst comprises, for example, nickel, such as Raney nickel, and noble metals or their derivatives, for example oxides, such as palladium or platinum oxide, which may be applied, if desired, to support materials, for example to carbon or calcium carbonate. The hydrogenation may preferably be carried out at pressures between 1 and about 100 atm. and at room temperature between about -80° to about 200°C, in particular between room temperature and about 100°C.

The removal of a trityl or tert-butyl group, respectively, can be achieved by treating corresponding protected compounds with an acid, especially under mild conditions.

Step (d'):

The isolation <u>Step (d')</u> of a compound of formula (IV b) is carried out according to conventional isolation methods, such as by crystallizing the resulting compound of formula (IV b) from the reaction mixture – if desired or necessary after work-up, especially by extraction - or by chromatography of the reaction mixture.

The conversion of an acid of formula (IV b) into a salt is carried out in a manner known per se. Thus, for example, a salt with a base of compounds of the formula (IV b) is obtained by treating the acid form with a base. Salts with a base can, on the other hand, be converted into the acid (free compound) in a customary manner, and salts with a base can be converted, for example, by treating with a suitable acid agent.

Accordingly, variable R comprises the meanings of variables Rx, Ry and also represents formyl as well as the core elements corresponding to angiotensin II receptor antagonists, especially those that are listed in the above table.

Another embodiment of the present invention is the use of a compound of formulae (VI a), (VI b), or (VI c) for the manufacture of a compound of formula (IV a), especially (IV b) or tautomer or a salt thereof, by carrying out corresponding reaction steps as described hereinbefore and hereinafter.

A further preferred embodiment of the present invention is a process for the manufacture of a compound of formula
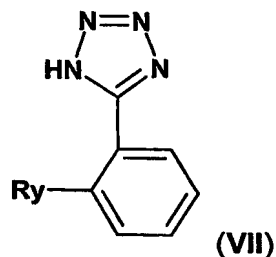

(VII')
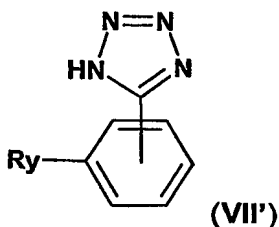
a tautomeric form thereof, wherein Ry represents C_1-C_8-alkyl such as methyl; C_1-C_8-alkyl substituted by X' and X' being halogen, sulphonyloxy, hydroxyl, protected hydroxyl, such as bromomethyl, or an acetal of formyl; comprising reacting a compound of formula (VII a')
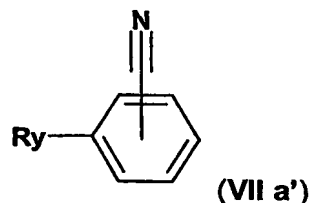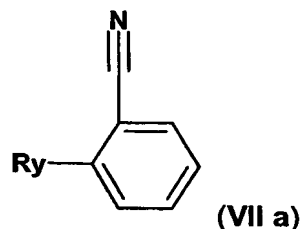
(VII a')

with a compound of formula **(R₁)(R₂)M-N₃ (II b)**, wherein R_1 and R_2, independently of one another, represent an organic residue; and isolating the resulting compound of formula (VII').

A further preferred embodiment of the present invention is a process for the manufacture of a compound of formula

(VII)

a tautomeric form thereof, wherein Ry represents C_1-C_8-alkyl such as methyl; C_1-C_8-alkyl substituted by X' and X' being halogen, sulphonyloxy, hydroxyl, protected hydroxyl, such as bromomethyl, formyl or an acetal thereof; comprising reacting a compound of formula (VII a)

(VII a)

with a compound of formula **(R₁)(R₂)M-N₃ (II b)**, wherein R_1 and R_2, independently of one another, represent an organic residue; and isolating the resulting compound of formula (VII).

The present invention likewise relates to the above reaction. Furthermore, the present invention relates to the compounds of formula (VII) or a tautomer or a salt thereof in a form being completely free of tin. The present invention also relates to compounds of formula (VII) whenever obtained according to above reaction.

The isolation step of a compound of formulae (VI) or (VII) or (VII'), respectively, is carried out according to conventional isolation methods, such as by crystallizing the resulting compound

of formula (VI)) or (VII), respectively, from the reaction mixture or by chromatography of the reaction mixture.

The conversion of an acid into a salt is carried out in a manner known per se. Thus, for example, a salt with a base is obtained by treating the acid form with a base. Salts with a base can, on the other hand, be converted into the acid (free compound) in a customary manner, and salts with a base can be converted, for example, by treating with a suitable acid agent.

The present invention likewise relates to a compound of formulae (I), (IV), (IV b), (V), (VI), (VII), (VII') or a tautomer or salt thereof in a form being completely free of tin.

The present invention likewise relates to the use of a compound of formula (II b) in a process for the manufacture of a compound of formulae (I), (IV), (IV b), (V), (VI), (VII), (VII') or a tautomer or salt thereof, especially in a form being completely free of tin.

The invention relates to the compounds obtained according any process of the present invention.

The examples outline specific embodiments of the present invention, but are not to limit the scope of the invention.

<u>Example 1:</u>   5-(2-Chlorophenyl)-1H-tetrazole
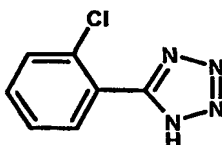
20 mmol (1.3 g) of sodium azide are charged to a 25 ml flask under argon atmosphere followed by slow addition (via syringe) of 11 ml of a solution of diethyl aluminium chloride (1.8 molar in toluene), 20 mmol, at 0 °C under stirring. The suspension is stirred over night at room temperature. Then 2.06 g (15 mmol) solid 2-chloro-benzonitrile are added and the mixture is heated at external temperature of 90 °C for 9 hours. After this time the conversion was 91.5 % (HPLC). For complete conversion (> 99.5 %, HPLC) the reaction mixture is kept for additional 6 hours at 90 °C. For work up the reaction mixture was quenched at 0 °C

under stirring on 20 ml HCl (6N) which contains 2.6 g of NaNO$_2$ to destroy excess hydrazoic acid. The thick white precipitate which is formed (product) is stirred at 0 °C for additional 1 hour and then filtered and dried over night at 50 °C to give the white crystalline product.

<u>m.p.</u> 173 - 175 °C

<u>Tlc:</u> R$_f$-value: 0.48, toluene : EtOAc : AcOH (20 : 20 : 1); SiO$_2$ -plates.

<u>Example 2:</u>   5-(2-Hydroxyphenyl)-1H-tetrazole
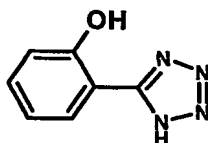
<u>Method A:</u>

286 mg of granular sodium azide (4.4 mmol) are added to a cold solution of diethyl aluminium chloride (4.4 mmol, 1M in toluene) and the mixture is stirred at room temperature for 4 hours (h).

A solution of 2-hydroxybenzonitrile (4 mmol, 476 mg) in 3 ml of toluene, cooled at 0°C, is treated with 2.2 ml of triethyl aluminium (4 mmol, 1.8 M in toluene). The mixture reaction is warmed to room temperature and stirred for 1 hour. The mixture is cooled to 0°C, treated with the solution of diethyl aluminium azide, gradually warmed to 85°C and stirred over two days. The reaction mixture is cooled to -10°C and treated drop wise with 7 ml of HCl 6 N. 10 ml of ethyl acetate are added and the mixture is extracted once with 10 ml of water, once with 10 ml of NaCl saturated. The combined aqueous layers are extracted three times with 10 ml of ethyl acetate. The combined organic phases are dried over Na$_2$SO$_4$. The solvent is removed to give the crude product.

<u>Method B:</u>

260 mg of granular sodium azide (4 mmol) is added to a cold solution of diethyl aluminium chloride (4 mmol, 1.8 M in toluene) diluted with 10 ml of toluene, and the mixture is stirred at room temperature for 4 hours. The stirred solution is cooled at 0°C and 238 mg of 2-hydroxybenzonitrile (2 mmol) are added. The reaction mixture is warmed to 80°C and stirred over night. After 20 hours the conversions was 83 %. Then the temperature is increased to 100°C and stirred 12 hours. At a conversion of around 90% the reaction is worked up. The

reaction mixture is cooled to 0°C and treated drop wise with 7 ml of HCl 6 M, 5 ml of water, 10 ml of ethyl acetate, 8 ml of saturated NaCl (sat.) and extracted. The organic phase is reextracted twice with 20 ml of water. The combined aqueous layers are extracted twice with 20 ml of ethyl acetate. The combining organic phases are dried over Na_2SO_4. The solvent is removed to give the crude product. The crude product is crystallized from ethyl acetate to give the pure product.
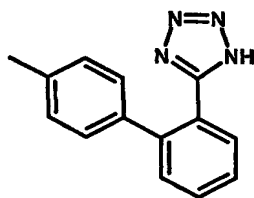
m.p.: 220 – 222 ° C,

Tlc: Rf – value: 0.46, toluene : EtOAc : AcOH (20 : 20 : 1).

HPLC:

Hewlett Packard, solvents. H_3PO4, acetonitrile/water; flow: 2 ml/min; injection: 5.0 µl; wavelength 220 nm, 40 °C. Column: Merck, Chromolith Performance, RP-18e 100-4.6 mm;   Ret. Time: 4.12 min.

Example 3a: 5-(4'-methylbiphenyl-2-yl)-1H-tetrazole

A 20 ml flask is dried under argon and then charged with 7 ml of diisobutylaluminium fluoride (1 molar in hexane) followed by 5 ml of toluene and 455 mg of NaN_3 (7 mmol). After stirring the suspension for 4 hours at room temperature 966 mg of solid ortho-tolylbenzonitrile (OTBN) is added at 0 ° C in one portion. The suspension is warmed up to 130 °C (ext. temp.) with an internal temperature of 100 °C. After 44 h at 130 °C (ext. temp.) the conversion is > 93 %. The reaction mixture was quenched in hydrochloric acid (6 molar). After addition of 10 ml of toluene the layers are separated, the organic layer is washed twice with 20 ml of water, dried over sodium sulfate and evaporated to give a crystalline residue of the product.

Physicochemical data see example 3b.

Example 3b: 5-(4'-methylbiphenyl-2-yl)-1H-tetrazole

Same reaction as in example 3a was carried out, but with diethylaluminium azide at higher concentration and higher temperatur:

Under similar conditions with diethylaluminium azide (prepared from diethylaluminium chloride and NaN₃) in toluene and OTBN a conversion of 98.5 % was obtained after 40 hours at internal temperature of ca. 110 °C (reflux), external temperatur 135 °C.

A dry 50 ml flask is charged with 5 ml toluene and 1.3 g (20 mmol) of dry solid sodium azide. The stirred suspension is cooled to 0 °C and 11 ml of a 1.8 molar solution of diethylaluminium chloride (20 mmol) is added via syringe during 10 minutes. The suspension is stirred for 4 to 6 hours or over night at room temperature. Then the suspension is cooled to 0 °C and a solution of o-tolylbenzonitrile (2.1 g, 11 mmol) in 5 ml toluene is added dropwise during 5 minutes. The stirred suspension is heated up to reflux and after 7 hours a conversion of 54.5 % (HPLC) is obtained. After refluxing over night (17 h) a conversion of 92 % is observed. After 40 h the conversion is > 98.5 %. Thereafter the reaction is quenched by droping the reaction mixture to cold 2 N hydrochloric acid (50 ml) under stirring to give a white precipitate which is dissolved by addition of 20 ml of acetonitrile to give a clear biphasic solution. The product is extracted with 50 ml of isopropyl acetate. The organic phase is treated with aqueous pottasium carbonate solution (pH 10) until all product is dissolved in the aqueous layer as the potassium salt. Then the basic aqueous phase is adjusted to pH 1-2 by addition of ca. 90 ml of 2N HCl. The product is extracted twice with 50 ml of isopropyl acetate and the organic phase is evaporated under reduced pressure to give after drying in vacuum the very pure, white crystalline product.

m.p.: 150 – 152 ° C;   (Ref. substance: DiPharma sample: m.p. 149-151 °C)

Tlc: R$_f$ -value: 0.56, (Toluene : EtOAc : AcOH = 20 : 20 : 1), SiO₂-plate (Merck KgaA)

Example 4 a: 5-(4'-Hydroxymethylbiphenyl-2-yl)-1H-tetrazole
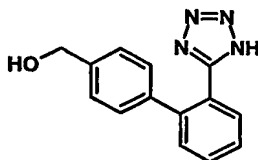
[2'-(2H-Tetrazol-5-yl)-
biphenyl-4-yl]-methanol

1.235 g of granular sodium azide (19 mmol) are added to a cold solution of diisobutyl aluminium chloride (19 mmol, 1.8M in toluene) diluted in 5 ml of toluene and the mixture is stirred at room temperature over the night to give diisobutyl aluminium azide.

2.1 g of 4'-hydroxymethyl-biphenyl-2-carbonitrile (10 mmol), are treated, in a drop wise manner at 0 °C with 5.52 ml of triethyl aluminium (10 mmol, 1.8M in toluene). The reaction mixture is stirred for 5 minutes. After that, the clear colourless reaction mixture is added to the solution of diisobutyl aluminium azide (19 mmol), gradually warmed to an internal temperature of about 100°C and stirred over the night (conversion 95.7%). For the work up the reaction mixture is cooled to 0°C and added dropwise to a solution of 30 ml of HCl (2 N) containing 1.38g of $NaNO_2$ (20 mmol) (cooled to 0°C). 40 ml of iso-propyl acetate are added and the mixture is extracted once with 15 ml of HCl 2N, once with 20 ml of water. The combining aqueous layers are extracted twice with 10 ml of isopropyl acetate. The organic phase is extracted three times with 15 ml portions of an aqueous solution of K_2CO_3 (10%). The aqueous phase is washed once with 15 ml of isopropyl acetate. HCl (2 N) is added to the aqueous phase to adjust the pH to 2, and the solution is extracted three times with 20 ml portion of isopropyl acetate. The combining organic phase is washed once with 20 ml of water and the solvent is removed to give the crude product. The crude product is crystallized from ethyl acetate and isopropyl ether to give the pure product.

m.p.: 137 – 139 ° C;

Tlc: Rf-value: 0.21, (toluene : EtOAc : AcOH = 20 : 20 : 1), SiO_2 - plates (Merck KgaA)
        Catalog -Nr. 1.05628.0001)

Example 4 b: The reaction as in Example can also be carried out with diethyl aluminium azide at higher concentration and higher temperature.

Example 5:   Synthesis of 5-((E)-Styryl-2H-tetrazole
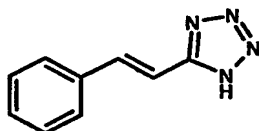
Procedure:

To a 50 ml, three necked round bottomed flask, 10 ml of a solution of diisobutyl aluminium fluoride (10 mmol, 1 M in hexane), diluted in 10 ml of toluene, are added. NaN_3 is added to

the solution (650 mg, 10 mmol), and the mixture is stirred at room temperature for 4h. The stirred solution is cooled at 0°C with an ice-bath. 0.62 ml of cinnamonitrile (5 mmol) diluted in 3 ml of toluene are added, the mixture is warmed to 90°C (i.t.) and stirred over the night. The temperature is increased to 105°C (i.t.) and stirred over the night. After a total time of 70 hours (no complete conversion) the reaction was quenched. The mixture is cooled to -10°C and treated drop wise with 8 ml of HCl (6N) (pH1). The aqueous phase is extracted with 10 ml of ethyl acetate. The organic phase is washed twice with 10 ml portion of NaCl sat. and then extracted twice with 10 ml portion of KHCO$_3$. The water phase is washed twice with 10 ml portion of ethyl acetate and then treated with HCl to pH 1-2 and extracted three times with ethyl acetate. The organic phase is dried over Na$_2$SO$_4$ and the solvent removed in vacuum to give after drying the title product.

m.p.:   158 – 160 °C

Tlc: Rf-value: 0.46   (Toluene : EtOAc : AcOH (20 : 20 :1)

Example 6:   5-(2-Fluorophenyl)-1H-tetrazole,
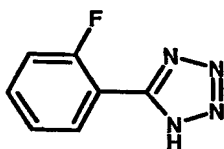
20 mmol (1.3 g) of sodium azide are charged to a 25 ml flask under argon atmosphere followed by slow addition (via syringe) of 11 ml of a solution of diethyl aluminium chloride (1.8 molar in toluene), 20 mmol, at 0 °C under stirring. The suspension is stirred over night at room temperature. Then 1.8 g (1.2 ml), (15 mmol), 2-fluoro-benzonitrile are added and the mixture is heated at external temperature of 90 °C for 7 hours. After this time the conversion was complete (HPLC). Work up: The reaction mixture is quenched on 20 ml HCl (2 molar) containing 20 mmol NaNO$_2$ at 0 °C to destroy hydrazoic acid which is formed from excess azide. The precipitate which is formed is dissolved by addition of 20 ml acetonitrile to give a clear biphasic solution. The aqueous phase is extracted twice with each 10 ml ethyl acetate. The combined organic phases are extracted with 15 ml of an aqueous solution (10 %) of potassium carbonate and adjusted to pH 10. The organic phase is extracted twice with 10 ml of water. The combined aqueous basic phases are neutralized with 2 N HCl and the pH is adjusted to pH 1-2. The product is extracted with ethyl acetate. The ethyl acetate is evaporated under reduced pressure to give a crystalline residue which is further dried in vacuo at 50 °C to give a white crystalline solid.

m.p.: 158 – 160 °C.

Tlc: Rf –value: 0.48 (toluene : EtOAc : AcOH = 20 : 20 : 1), SiO$_2$ - plates

Example 7:   4'-Hydroxymethyl-biphenyl-2-carbonitrile

OAc - derivative   4'-Hydroxymethyl-biphenyl-
2-carbonitrile
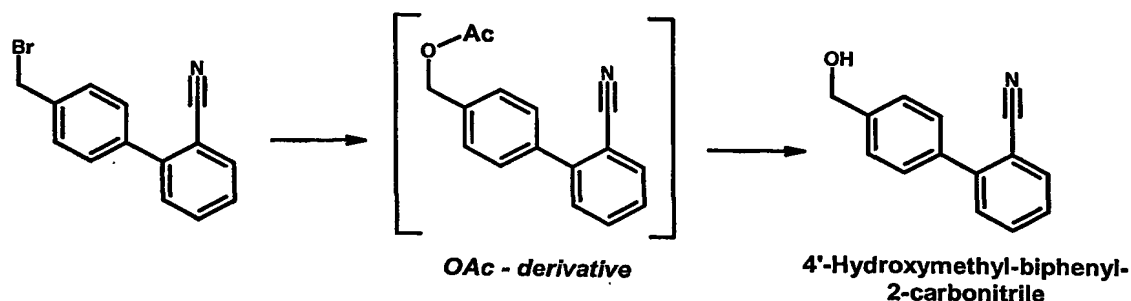
One pot PTC preparation of 4'-hydroxymethyl-biphenyl-2-carbonitrile from 4'-bromomethyl-biphenyl-2-carbonitrile without isolation of the intermediate OAc (O-acetyl) derivative.

A 750 ml flask is charged with 54.4 g (0.2 mol) of 4'-bromomethyl-biphenyl-2-carbonitrile and 250 ml of toluene. To this suspension is added a solution of 30 g (0.3 mol) of potassium acetate in 15 ml of water. The heterogeneous mixture is heated up to an internal temperature of 90 ° C to become a clear biphasic solution. After 12 hours at an internal temperature of 90 °C the conversion to the OAc derivative is complete. The biphasic mixture is cooled down to internal temperature of about 50 °C followed by addition of 150 ml NaOH (2N). The mixture is heated up to an internal temperature of ca. 70 °C (extern. temp. 80 °C). After 5 hours at this temperature the PTC saponification is complete (100 % conversion, HPLC). Additional 150 ml toluene is added and the warm reaction solution (ca. 50 °C) is washed three times with 50 ml of hot water until the pH is around 7. The toluene phase is evaporated under reduced pressure and the resulting crystalline residue is dried at 50 °C over 24 hours in vacuum to give the white crystalline product with 98 % purity (HPLC) and a water content of 0.23 %.

m.p.: 118-120 °C

Tlc: : Rf –value: 0.45, (toluene : EtOAc : AcOH = 20 : 20 : 1), SiO$_2$ - plate

Example 8 a: 5-(4'-Formyl-biphenyl-2-yl)-1H-tetrazole or

2'-(2H-Tetrazol-5-yl)-biphenyl-4-carbaldehyd
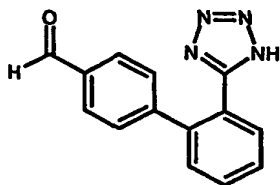
1.01 g (4 mmol) of 5-(4'-hydroxymethylbiphenyl-2-yl)-1H-tetrazole is dissolved in 7 ml of a 10 % aqueous solution of potassium carbonate. To the stirred solution is added an aqueous solution (ca. 8 %) of sodium hypochlorite (eau de Labarraque) at room temperature. After 40 min. a conversion of 50 % to the aldehyde is observed. After 3.5 hours additional 1.5 ml sodium hypochlorite is added at room temperature. After a total reaction time of 7 hours a conversion of > 93 % is observed. Stirring over night at 0 °C improves the conversion to 97 %. The reaction mixture is quenched with 20 % aqueous sodium hydrogen sulfite solution (5 ml) under stirring for 1 hour to destroy excess hypochlorite. Then 2-methyl-2-butene (1.5 ml) is added and the product is precipitated by carefully dropping 10 ml of 6 N HCl at 0 °C to the mixture under stirring. The product is extracted with ethyl acetate and the solvent is evaporated to dryness to give the solid product.

m.p.:   184 – 186 °C

Tlc: Rf –value: 0.31, (toluene : EtOAc : AcOH = 20 : 20 : 1), SiO$_2$ – plate.

Example 8 b: Compound (VI c), 5-(4'-hydroxymethylbiphenyl-2-yl)-1H-tetrazole, 504 mg (2 mmol) is suspended in a mixture of 2 ml of toluene and 1 ml of dichloromethane. The suspension is cooled to 0 °C and 0.42 ml of nitric acid (ca. 6 mmol), (65 %, d = 1.4) is added in one portion at 0 °C under stirring which results in a clear slightly yellow solution. The ice bath is removed and stirring is continued at room temperature for ca. 1 h. After 1 h the product (VI) is crystallizing directly from the reaction mixture. The slurry is cooled to 0 °C for 1 h and then filtered to give after drying in vacuum 400 mg of pure aldehyde (VI).

Example 9:   5-(2-Chlorophenyl)-1H-tetrazole   (with dibutylboron azide)
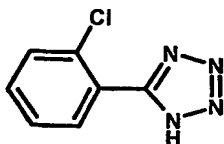

A dry 25 ml flask is charged with 10 ml (10 mmol) of a heptane solution of dibutyl boryl triflate (1 molar) under Argon. To this solution is added 650 mg (10 mmol) of sodium azide.

The suspension is stirred over night at room temperature to give a dibutylboron azide. To the suspension is added 1.0 g (7.7 mmol) 2-chlorobenzo nitrile as a solid in one portion. The reaction mixture is heated up to 130 ° C external temperature. After

5 hours the conversion to the desired product is only 5 %. Additional 5 ml of toluene is added and refluxing is continued over night. After 24 hours the conversion is 27 %.

After additional 24 h refluxing at 130 ° C (ext. temp.) the conversion is 35 % (HPLC).

The reaction is stopped by carefully quenching the yellow suspension on 6 N HCl. The product is extracted to the water phase with 2 x 10 ml of potassium carbonate solution. The water layer is adjusted to pH 1 with 6N HCl and the product is extracted with ethyl acetate. The solvent is evaporated to dryness to give an off-white solid residue.

Tlc: R_f-value: 0.48, toluene : EtOAc : AcOH (20 : 20 : 1); SiO$_2$ -plate.

Example 10:   5-(4-Chlorophenyl)-1H-tetrazole
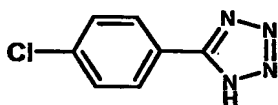
Procedure:

292 mg of granular sodium azide (4.5 mmol) are added to a cold solution of diethyl aluminum chloride (4.5 mmol, 1.8 M in toluene) diluted in 2.5 ml of toluene, and the mixture is stirred at room temperature for 4h. 473 mg of 4-Chlorobenzonitrile are added to the stirred solution, and the reaction mixture is heated up to 135°C (e.t.) and stirred over the night. Complete conversion is observed by HPLC. 5 ml of toluene are added to the mixture, then the solution is added drop wise to a cold solution of HCl 6N. 10 ml of ethyl acetate are added and the solution extracted. The aqueous phase is washed twice with 10 ml portion of ethyl acetate. The combined organic phases are washed with 10 ml portion of HCl 2N and finally with 10 ml of water. The solvent is removed and the product is dried in vacuum at 60°C over the night to give the product.
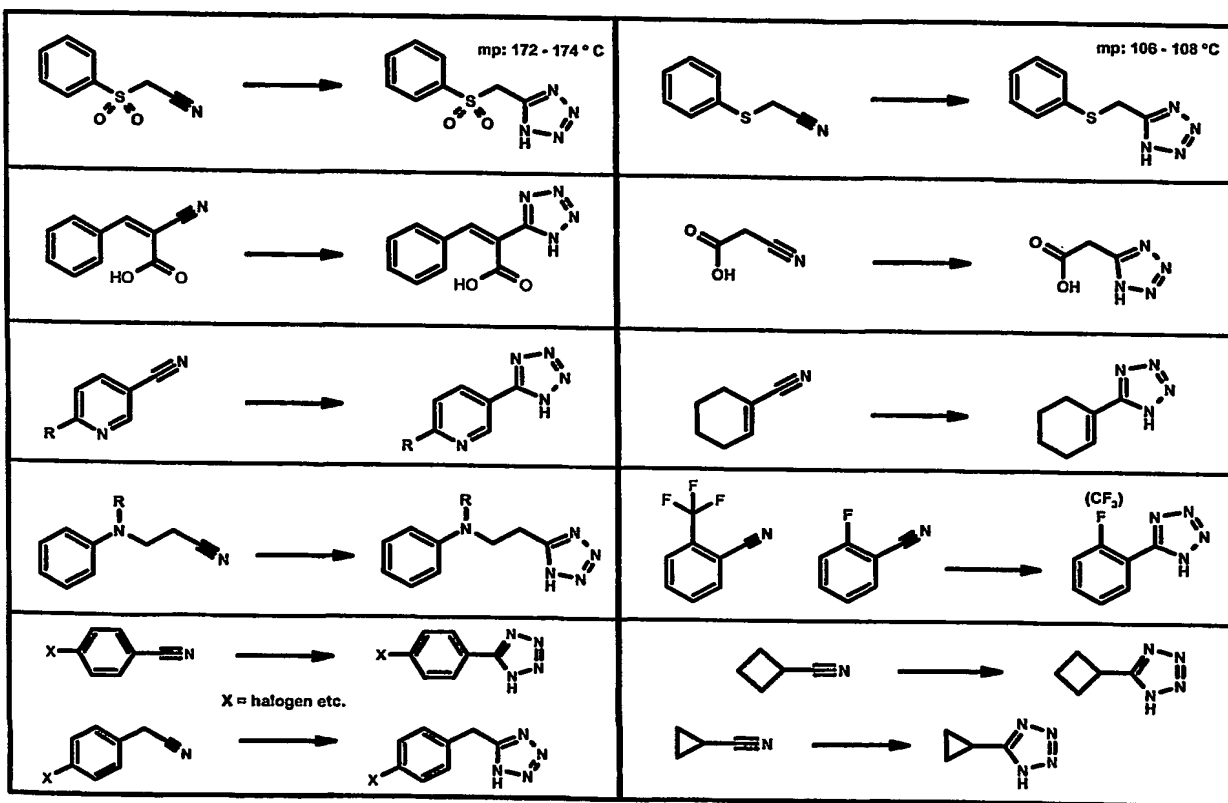
m.p.: 255 – 257 °C

Tlc: R_f-value: 0.40,   toluene : EtOAc : AcOH (20 : 20 : 1); SiO$_2$ -plate.

HPLC: Hewlett Packard, solvents. H_3PO_4, acetonitrile/water; flow: 2 ml/min; injection: 5.0 µl; wavelength 220 nm, 40 °C; flow: 2 ml/min; injection: 5.0 µl; Column: *Merck, Chromolith Performance RP-18e 100-4.6 mm.*   Rt. Time: 6.184 min

Examples 11 a) to 11 l):

The following table (Examples 11 a) to 11 l) should further illustrate the present invention. When applying the method of the present invention, tetrazole compounds of formula (I) are obtainable starting from nitrile compounds of formula (II a):

Using the technology as described above, especially as described in the examples, following compounds can be obtained:
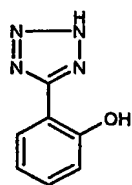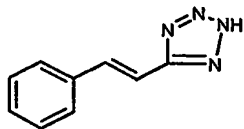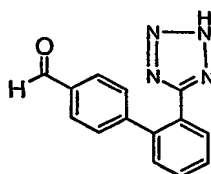
m.p. 220-222°C -   m.p. 158-160°C -   m.p. 255-257°C
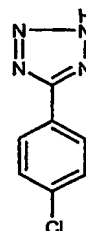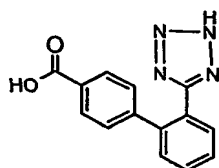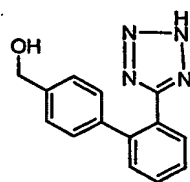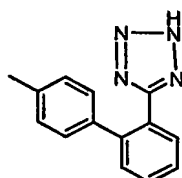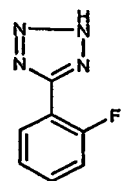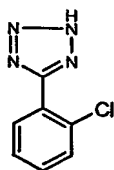
m.p. 253-255°C -   Rf: 0.31

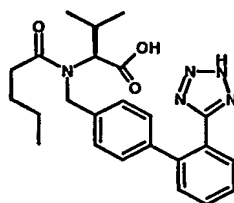m.p. 140-141°C -   m.p. 150-152°C

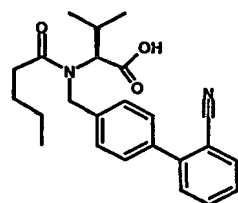m.p. 158-160°C -   173-175°C

Example 12:

1. AlR₃
2. R₂Al-N₃
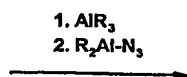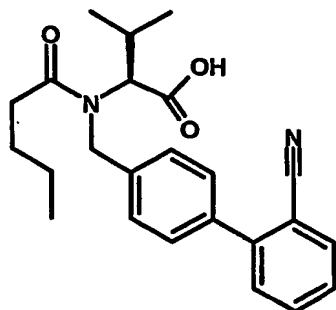
Valsartan (DIOVAN)

A suspension of 5 mmol of formula

,

1.96 g 5 mmol), in 5 ml of toluene and 2.7 ml of a 1.8 molar solution of triethyl aluminium in dry toluene are slowly combined at 0° C. The separately prepared diisobutyl-Al-azid (7 mmol) in toluene is added to the suspension and finally the mixture is heated to an internal temperature of ca. 110 °C over night. HPLC control shows after 14 h ca. 50 % conversion. Another portion of diisobutyl aluminium azid (4 mmol) is added and heating at reflux temperature at 130 °C is continued for further 12 hours. HPLC shows a conversion of ca. 77 % to the desired product (Valsartan DS) and ca. 23% of starting material. After cooling down to room temperature the reaction mixture was quenched onto a mixture of an aqueous solution of 50 mmol of $NaNO_2$ in 40 ml of 2N hydrochloric acid. Additional 20 ml of 2N HCl is added under stirring to dissolve precipitated aluminium hydroxide. Finally the product is isolated from the aqueous phase by extraction with i-propyl acetate. The combined organic phases (toluene/i-PrOAc) are washed with 30 ml of water and evaporated to dryness in vacuum to give crude oily valsartan which contained still ca. 23 % of starting material. The product can be purified by careful extraction with $KHCO_3$ from the organic phase to the aqueous phase as the bis potassium salt and subsequent adjustment with hydrochloric acid and back extraction to i-propyl acetate.

Example 13:

Losartan via Diethyl-Al-Azid - Cycloaddition
3 Step Syntheses ex Br-OTBN

X = Cl, Br, J, -O-SO₂-R

MW : 377.88

MW : 422.92

Losartan
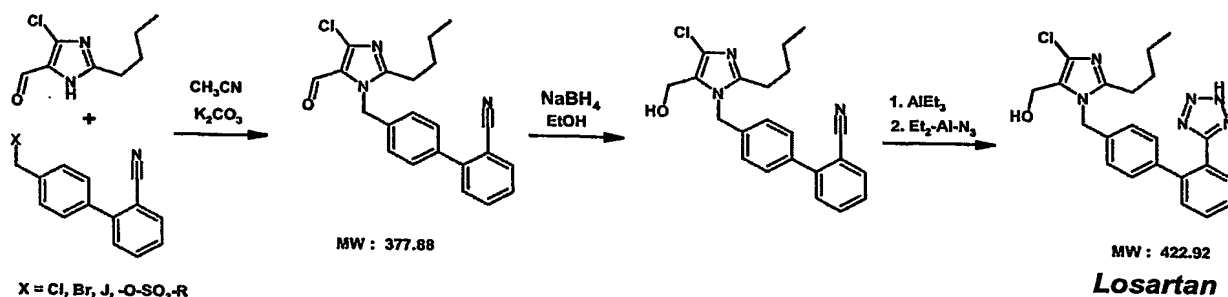
Reaction Step 1:   Disclosed in

1) K. Srinivas et al., Synthesis, 2004, (4), 506

2) R. D. Larsen et al., J. Org. Chem., 59, 6391 (1994)

3) T. Kato & Y. Shida, EP 578125 A1 (19940112)

Reaction Step 2. Reduction of the aldehyde with $NaBH_4$ to form the corresponding alcohol:l


3.78 g (10 mmol) of "5-formyl-imidazol-1-ylmethyl-biphenyl-2-carbonitrile" are suspended in 50 ml of ethanol. To this suspension is added in 2 portions 152 mg (4 mmol) of $NaBH_4$ under stirring at 10 °C. After stirring for 2-3 hours the reaction is quenched by addition of 10 ml 2N HCl. The reaction mixture is concentrated in vacuum and finally diluted with 25 ml of water. The aqueous phase is extracted 3 times with 30 ml of ethyl acetate. The organic phases are combined and evaporated to dryness to give an almost white solid residue which is dried in vacuum. The crude "alcohol" is used in the next step without further purification.

Reaction Step 3. Example for "in-situ-protection" with $AlEt_3$ and subsequent cycloaddition with diethyl-Al-azide and working up to LOSARTAN.

1.9 g (5 mmol) of the „hydroxymethyl-imidazol-1-ylmethyl biphenylcarbonitrile" from the previous step is suspended in 10 ml of dry toluene under argon. To this suspension is added at room temperature under stirring 2.8 ml of a 1.8 molar solution of $AlEt_3$ in toluene. Stirring of the suspension was continued for additional 3 hours. Then a solution of 10 mmol diethyl aluminium azide in toluene, which is prepared in a separate flask, is added via syringe. (This 10 mmol of Et_2Al-N_3 was prepared by stirring 10 mmol of Et_2AlCl and 10 mmol

of NaN₃ in toluene at room temperature over night to give a white suspension of NaCl, but the diethyl aluminium azide is dissolved in toluene). The rection mixture is heated to reflux (~111 °C), external temperature ca. 140 °C. conversion is controlled by HPLC analysis. After refluxing for 24 hours the reaction mixture was cooled to room temperature and finally quenched on an aqueous solution of 40 mmol of $NaNO_2$ in 40 ml of 2N hydrochloric acid. Then additional 20 ml of 2N HCl is added under stirring to dissolve the precipitated Aluminium hydroxide. Finally the product was isolated from the aqueous phase by extraction with ethyl acetate. The combined organic phases (toluene/EtOAc) are washed 2 times with 25 ml of water and evaporated to dryness in vacuum to give crude Losartan. The crude Losartan can be purified by crystallization from CH_3CN or CH_3CN /water mixtures, according to literature; (J.O.C., 59, 6391 (1994)).

Example 14:
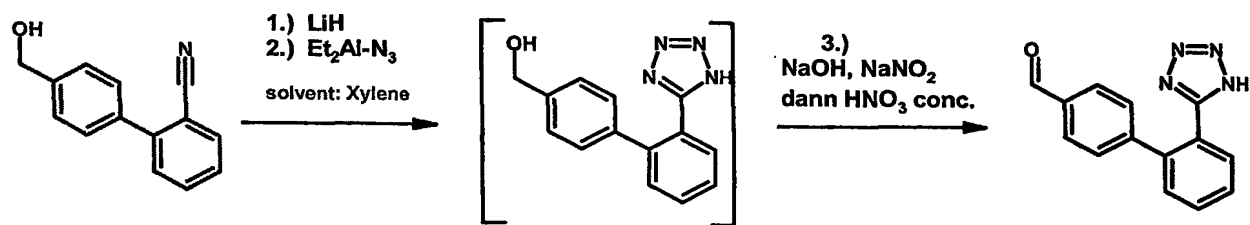
16.74 g (80 mmol) of the "4-hydroxymethyl-biphenyl-2-carbonitrile" is suspended in 100 ml of dry xylene (isomer mixture) under argon. To this suspension is added at room temperature under stirring 0.636g (80 mmol) of lithium hydride. The suspension is stirred for an additional 4 hours at 120°C external temperature and a solution of 160 mmol diethylaluminium azide in toluene (which is prepared separately by stirring 160 mmol of diethylaluminium chloride and 160 mmol of sodium azide in xylene [isomer mixture] at room temperature overnight) is added via syringe. The reaction mixture is heated to reflux (~120 °C), external temperature ca. 140 °C. Conversion is controlled by HPLC analysis. After refluxing for 24 hours the reaction mixture is cooled to room temperature and finally quenched with a solution of 300mmol of sodium nitrite and of 15% sodium hydroxide (240 mmol). Finally 95 ml of conc. HCl is added under stirring. To the resulting suspension is added at room temperature under stirring 31g (320 mmol) of 65% nitric acid. The suspension is stirred for an additional 6 hours at 60°C external temperature (internal

Temperature = 55°C). Finally the product is isolated by filtration. The. crude 2'-(1H-tetrazol-5-yl)-biphenyl-4-carbaldehyde is obtained..

Example 15:

a) Preparation of 3-methyl-2{[1-[2'-(1H-tetrazol-5-yl)-biphenyl-4-yl]-meth-(E/Z)-ylidene]-amino}-butyric acid
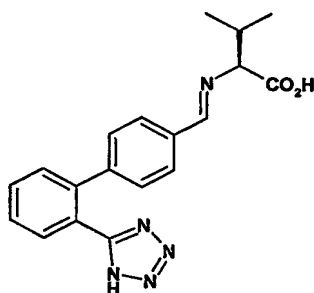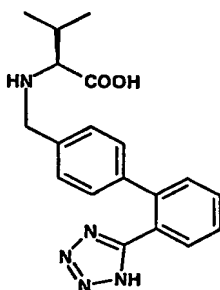

Aqueous sodium hydroxide solution 30% (4.2 ml; 31.5 mmol) is added to a stirred suspension of L-Valine (2.43 g; 20.8 mmol) and 2'-(1H-tetrazol-5-yl)-biphenyl-4-carbaldehyde (5 g; 19.6 mmol), in water (20 ml) at room temperature, until pH 11 is reached. The resulting solution is stirred at room temperature for 15 minutes. The clear solution is evaporated at 60°C in vacuo, and remaining water is azeotropically removed with 10 ml 1-butanol.

^{1}H NMR (CD$_3$OD, 300MHz):

δ= 8.21 (CH=N, s), 7.67 (C$_6$H$_5$-CH, d), 7.40-7.60 (4 C$_6$H$_5$-CH, m), 7.18 (C$_6$H$_5$-CH, d), 3.42 (CH, d), 2.31 (CH, m), 0.98 (CH$_3$, d), 0.82 (CH$_3$, d).

b1) Preparation of (S)-3-Methyl-2-((2'-(1H-tetrazol-5-yl)-biphenyl-4-ylmethyl)-amino)-butyric acid

Aqueous sodium hydroxide solution 2.0 M (approximately 100 ml; 200 mmol) is added to a stirred suspension of L-Valin (11.8 g; 100 mmol) and 2'-(1H-tetrazol-5-yl)-biphenyl-4-carbal-dehyde (25.1 g; 100 mmol) in water (100 ml) at room temperature, until pH 11 is reached. The resulting clear solution is evaporated at 60°C in vacuo, and remaining water is azeotro-pically removed with 1-butanol. The residue (imine as a solid foam) is dissolved in absolute ethanol (300 ml), and sodium borohydride (3.78 g; 100 mmol) is added in portions to the solution at 0-5°C. The reaction mixture is stirred for 30 min at 0-5°C, and, it the reaction is complete (HPLC), quenched by addition of water (100 ml) and hydrochloric acid 2.0 M (80 ml; 160 mmol). The organic solvent (ethanol) is stripped off from the clear solution (pH 7) at 50°C in vacuo. The remaining aqueous concentrate is adjusted to pH 2 by slow addition of hydrochloric acid 2.0 M (approximately 70 ml; 140 mmol) at 40°C. During the addition the desired product precipitates. It is collected by filtration, washed with water and dried in vacuo. The crude product is suspended in methanol at 50°C, and the slurry is cooled to room temperature. (S)-3-methyl-2-((2'-(1H-tetrazol-5-yl)-biphenyl-4-yl-methyl)-amino)-butyric acid is collected by filtration and then dried in vacuo.

b2)   Alternatively, (S)-3-methyl-2-((2'-(1H-tetrazol-5-yl)-biphenyl-4-yl-methyl)-amino)-butyric acid can be prepared e.g. as follows:

Aqueous sodium hydroxide solution 10 M (approximately 41 ml; 410 mmol) is added to a stirred suspension of L-Valine (24.8 g; 210 mmol) and 2'-(1H-tetrazol-5-yl)-biphenyl-4-carbal-dehyde (50 g; 200 mmol) in water (200 ml) at room temperature, until pH 11 is reached. The resulting clear solution is evaporated at 60°C in vacuo, and remaining water is azeotropically removed with 1-butanol. The residue (imine as a solid foam) is dissolved in methanol (600 ml), and sodium borohydride (3.13 g; 80 mmol) is added in portions to the solution at 0-5°C. The reaction mixture is stirred for 30 min at 0-5°C, and, if the reaction is complete (HPLC), quenched by addition of water (300 ml) and hydrochloric acid 2.0 M (160 ml; 320 mmol). The organic solvent (methanol) is stripped off from the clear solution (pH 7) at 50°C in vacuo. · The remaining aqueous concentrate is adjusted to pH 2 by slow addition of hydrochloric acid 2.0 M (approximately 90 ml) at 40°C. During the addition the desired product precipitates. It is collected by filtration, washed with water and dried in vacuo. The crude product is suspended in methanol at 50°C, and stirred for a few minutes. Then the slurry is cooled to

room temperature. (S)-3-methyl-2-((2'-(1H-tetrazol-5-yl)-biphenyl-4-yl-methyl)-amino)-butyric acid is collected by filtration and then dried in vacuo.

Enantiomeric excess (by HPLC): ee > 99.9 %

b3)   Alternatively, (S)-3-methyl-2-((2'-(1H-tetrazol-5-yl)-biphenyl-4-yl-methyl)-amino)-butyric acid can be prepared e.g. as follows:

Sodium hydroxide (1.71g; 41.89 mmol) is added in portions to a stirred suspension of L-Valine (2.48 g; 21 mmol) in 15 ml methanol. The mixture is stirred at room temperature for 30 minutes. Then 2'-(1H-tetrazol-5-yl)-biphenyl-4-carbaldehyde (5 g; 20 mmol) is added. The mixture becomes a clear solution after a few minutes. The mixture is then cooled to -5°C and sodium borohydride (0.315 g; 8 mmol) is added in portions to the solution. The temperature is maintained between 0-5°C during the addition. The resulting mixture is stirred for 2 hours at 0°C - the reaction completion is followed by HPLC – then quenched by addition of water (10 ml) and hydrochloric acid 37% (5.3 g) until pH is between 2-2.5. Further work-up and crystallisation are done according to example 1 b2).

Enantiomeric excess (by HPLC): ee > 99.9 %

b4)   Alternatively, (S)-3-methyl-2-((2'-(1H-tetrazol-5-yl)-biphenyl-4-yl-methyl)-amino)-butyric acid can be prepared e.g. as follows:

In a 50 ml steel autoclave, 3-methyl-2{[1-[2'-(1H-tetrazol-5-yl)-biphenyl-4-yl]-meth-(E/Z)-ylidene]-amino}-butyric acid (1.5 g; 3.2 mmol) and 5% Pt/C (7.5 mg, 5% wt/wt) is charged under argon. Then 15 ml methanol are added and the autoclave is sealed and flushed with argon and hydrogen. The pressure is set to 5 bars and the reaction stirred at room temperature. The reaction completion is monitored by HPLC. Then the autoclave is flushed with argon and the catalyst is filtered off. Further work-up and crystallisation are done similar to example 1 b2).


b5)   Alternatively, (S)-3-methyl-2-((2'-(1H-tetrazol-5-yl)-biphenyl-4-yl-methyl)-amino)-butyric acid can be prepared e.g. as follows:

2'-(1H-tetrazol-5-yl)-biphenyl-4-carbaldehyde (0.79 g; 3.2 mmol) and L-Valine (0.4 g; 3.4 mmol) are suspended in 15 ml methanol. Then sodium hydroxide is added (0.27 g; 6.72 mmol) and the reaction mixture is stirred at room temperature until a clear solution is obtained. 5% Pt/C (15.8 mg; 2 wt/wt-%) is added. The autoclave is sealed and flushed with argon and hydrogen. The pressure is set to 5 bars and the reaction is stirred at 60°C. The

reaction completion is monitored by HPLC. Then the autoclave is flushed with argon and the catalyst is filtered off. Further work-up and crystallisation are done similar to example 1 b2). Enantiomeric excess (by HPLC): ee > 99.9 %.

c)   Preparation of (S)-3-Methyl-2-{pentanoyl-[2'-(1H-tetrazol-5-yl)-biphenyl-4-ylmethyl]-amino}-butyric acid
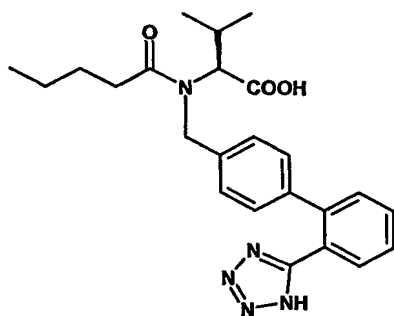
A suspension of (S)-3-methyl-2-((2'-(1H-tetrazol-5-yl)-biphenyl-4-ylmethyl)-amino)-butyric acid (17.6 g; 50.0 mmol) in 1,2-dimethoxyethan (116 g) is cooled to –5°C, and valeroyl-chloride (9.9 ml; 80 mmol) is added, followed by slow addition of pyridine (6.0 ml; 75 mmol) diluted with 1,2-dimethoxyethane (60 ml). [1] After completion of the reaction, the reaction mixture is quenched with methanol (18 ml). Finally water (50 ml) is added at room temperature, and after stirring for 1 h, the mixture is adjusted to pH 7.5 by addition of aqueous sodium carbonate solution 10% (~ 116 ml, 120 mmol) at 0°C. The organic solvents are stripped off at 50°C in vacuo. Ethylacetate (125 ml) is added to the remaining aqueous concentrate, and the two-phase system is adjusted to pH 2 at 0-5°C by addition of 2.0 M HCl (~ 98 ml). The organic phase is separated and concentrated at 45°C in vacuo (water is azeotropically removed). The crystallization of the product is initiated at 45°C and – after addition of cyclohexan (102 ml) – completed by cooling to –5°C. The solid is collected by filtration, and after drying at 50°C, (S)-3-methyl-2-{pentanoyl-[2'-(1H-tetrazol-5-yl)-biphenyl-4-ylmethyl]-amino} -butyric acid is received as a white powder.

Melting point: 108-110°C

Enantiomeric excess (by HPLC): ee > 99.5 %

[1] Alternatively pyridine and valeroylchloride can be added alternately: A suspension of (S)-3-methyl-2-((2'-(1H-tetrazol-5-yl)-biphenyl-4-ylmethyl)-amino)-butyric acid (25.5 g; 72.6 mmol) in 1,2-dimethoxyethane (126 g) is cooled to −10°C, and valeroylchloride (8.75 g; 72.6 mmol) is added over 15 min., followed by slow addition of a mixture (7.16 g) of pyridine (5.6 g) and water (1.5 g) over 61 min. After stirring for 30 min. valeroylchloride (5.3 g; 43.5 mmol) is added over 8 min., followed by slow addition over 30 min. of a mixture (4.3 g) of pyridine (3.4 g) and water (0.9 g). After each addition of pyridine the pH is controlled by sampling (hydrolyzed with water). The pH of the samples should always be below 2.5. The reaction is stirred for 25 min., then water (25.6 g) is added over 30 min. The mixture is stirred for another 30 min., then warmed to 23°C over 30 min. and stirred for another 2 hours. Adjustement of pH, remove of organic solvents by distillation, further work-up and crystallization is done as described in the example 1 c) above.